THE

STUDENT'S   HANDBOOK

OF

SURGICAL   OPERATIONS

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SURGICAL OPERATIONS

BY

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PREFACE.

THE present work is intended for the use of students who are preparing for the final examinations, or who need a handbook to assist them in carrying out operations upon the dead body. The book is abridged from the new edition of the author's large "Manual of Operative Surgery." That work aims at dealing in an exhaustive manner with the whole subject of operative surgery, or of treatment by operation. This handbook concerns itself only with the most essential and most commonly performed operations. All matters save such as deal with the actual technical details of operative surgery have been omitted. I have not discussed the general principles of operative surgery, nor have I embarked upon a critical consideration of the value of various methods. I have assumed that the reader is familiar with the anatomy of the district concerned in each section, and I have not entered into the after-treatment. I have given no description of instruments, and have left untouched the subjects of mortality and results.

The numerous intricate but rarely performed operations belonging to plastic surgery find no place in the present volume, save in so far as they concern the common

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deformities of the lip and palate. Certain operations, such as circumcision and the tapping of hydrocele, are not included, as I consider they come rather under the heading of minor surgery.

Those who need fuller information upon these and other matters that are involved in treatment by operation are referred to the larger and more comprehensive work.

The illustrations in this book are selected from among the four hundred and seventy-three that illustrate the new edition of the " Manual of Operative Surgery."

FREDERICK TREVES.

May, 1904.

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Part I.

LIGATURE OF ARTERIES.

CHAPTER I.

GENERAL CONSIDERATIONS.

Instruments Required.—1, scalpel; 2, two pairs of forceps, the ordinary dissecting one and a fine toothed pair; 3, small blunt hooks; 4, retractors; 5, long toothed forceps; 6, pressure forceps; 7, aneurysm needle; 8, ligatures; 9, vivisector's tool or dissecting instrument.

Small blunt hooks, with long shafts, are most convenient as retractors, especially to draw nerves and tendons out of the way.

There is considerable choice in the form of ligature used, the most essential points being (*a*) that it should be strong enough without being cumbrous or too rigid (if chromicised catgut be used it may cut through the wall of an artery or vein like wire), (*b*) that it should be resistant enough to last as a firm knot for at least ten days or so, and (*c*) that it should be perfectly aseptic when introduced into the tissues.

Kangaroo tendon, catgut, and soft silk of medium thickness may all be recommended. Whichever is em-

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ployed, it should have been kept in alcohol and not in an oily medium.

The ligature to be applied should always be selected with great care and well tested.

It should be allowed to soak for ten minutes or so in sterilised water, and should then be again examined and tested.

Position of the Patient. — The position of the patient will vary a little according to the artery to be tied. In general terms, it may be said that the surgeon should stand upon the side to be operated on, and that the incision on the right side is·more conveniently made from above downwards, and on the left side from below upwards.

Steps of the Operation.—These will be considered in the following order :—

> 1. The line of the artery.
> 2. The incision.
> 3. The exposure of the artery.
> 4. The opening of the sheath.
> 5. The passing of the ligature.

1. *The Line of the Artery.*—This line must be very accurately defined. It may differ from what is commonly given as the anatomical line of the vessel.

The posture of the limb, also, is of moment. In indicating the exact situation of the femoral or brachial arteries, for instance, it is essential that the limb should be placed in a certain position before the line is drawn.

2. *The Incision.*—The incision should—when possible—be so placed upon the line of the artery as to avoid superficial veins. It is most desirable that there should be little bleeding during the operation, that the wound should be " dry," and the view of the depths not embarrassed by pressure forceps.

The scalpel should be held in what is termed the dinner-knife position. The wound should be freely made and cleanly cut. There is a disposition to make the incision too small. A small wound carries with it special dangers

and difficulties, whereas a little increase in the length of the skin-cut does not add to the gravity of the procedure.

The knife should be entered at right angles to the surface, and should be in the same position when withdrawn. The surface wound should be of equal depth throughout. There should be no " tails " to the cut.

The skin should be steadied with the left hand while the integuments are being divided.

After the surface cut has been made, the next step is to divide the deep fascia, or aponeurosis. This is done by a clean cut made in the line of the original incision and carried the whole length of the wound.

A director is not required either at this or any other stage of the operation. In the ligature of arteries the director should be avoided as an unnecessary and dangerous weapon.

When the deep fascia has been exposed in a limb, the outlines of the underlying muscles and tendons are rendered more or less distinct. A gap between two adjacent muscles has usually to be followed in the operation. This gap is erroneously said to be indicated by a white or a yellow line.

In opening up the depth of the wound the posture of the limb may be so altered as to relax the muscles about the incision. It is better that this should not be done until the interspace has been well and clearly demonstrated.

The deep part of the wound should follow the line of the superficial incision, and should equal it in extent. The wound should not be funnel-shaped.

Retractors must be freely used. Every means must be adopted to expose the depths of the wound clearly. All bleeding must be checked as it is encountered. The wound should be kept dry to its very bottom.

Above all things, the operation must be conducted step by step. Each guiding point must be well made out before the next point is sought for. This circumstance is well illustrated by the operation for securing the lingual artery.

3. *The Exposure of the Artery.*—The artery should be sought for with the finger. As the tissues will be more

or less evenly stained with blood, the finger—in a deep wound especially—affords the best means of differentiating the artery, the veins, and a companion nerve.

To the touch the nerves feel firm, resisting, round, and cord-like. They cannot be flattened by the pressure of the finger. The veins greatly exceed the corresponding arteries in size. They often overlap these vessels. They feel soft and yielding, and thin-walled. They are easily compressed, and when so treated swell out upon the distal side. When the finger touches the compressed vein the vessel as a tube can scarcely be appreciated. In this respect it is very different from the artery. The artery feels firmer and more elastic. It is not unlike a thin indiarubber tube to the touch. It is movable, and often slips about under the finger in a characteristic manner. It can be compressed, but not so readily as the vein. When flattened out by the finger, an artery of moderate dimensions feels like a flat band or thong, thick and elastic, and hollowed out a little in the centre, so that the margins feel thicker than the median part. Above all, it pulsates.

There are many fallacies in this. The pulsations of the artery may be transmitted to the nerve (as in the case of the median nerve and the brachial), or to the companion vein. When the patient is under an anæsthetic, and when the pulse is feeble, or very rapid, the movement in the artery may be difficult to detect. If an aneurysm or pulsating growth exist, compression of the artery causes the pulsation in the tumour to cease.

There may be one companion vein or two—the *venæ comites.* All arteries below the knee are accompanied by venæ comites. All arteries of the arm, forearm, and hand are attended in like manner.

The arteries of the trunk, which are of small or of medium size, are for the most part accompanied by venæ comites; such are the pudic, the deep epigastric, the deep circumflex iliac, and the internal mammary.

The arteries in the head and neck are attended by single veins, the only noteworthy exception to this being the lingual artery.

The venæ comites lie close to the artery, one upon each side of it. They are apt to communicate with one another freely across the vessel by means of many transverse branches.

4. *The Opening of the Sheath.*—The artery is now reached. It remains to open the sheath, and to clear a part of the vessel for the passage of the aneurysm needle.

The sheath must be opened with the scalpel with infinite care and the most delicate precision. The knife must have a perfect cutting edge. A good light is essential, and a pair of trustworthy forceps by means of which it is possible to pick up a fine fold of tissue and hold it firmly.

The sheath is picked up over the *centre*, or median part, of the artery, in the form of a fold which is *transverse* to the long axis of the vessel. It must be picked up cleanly and entirely.

The transverse fold of the sheath is then incised. The cut should be clean, should be made in the *long axis* of the artery, and over the *centre* of the vessel. In length it should be from 5 to 10 mm.

When the sheath has been well divided, the serous-like space between it and the artery becomes at once evident.

The blade of the scalpel should be inclined obliquely— *i.e.* with the flat of the knife towards the artery.

The fold of the sheath must be held well up during the making of the incision. When once a good hold of the sheath has been obtained by the forceps the instrument must not be shifted.

In this part of the operation a director is not only useless but dangerous.

5. *The Passing of the Ligature.*—The original hold of the forceps upon the sheath should not be relaxed. The surgeon clears a way for the aneurysm needle with the vivisector's tool. He then takes the aneurysm needle in his right hand, and introduces its unthreaded point between the artery and the sheath for the purpose of clearing the former. The needle should be held with its concavity towards the vessel, and it should be gently insinuated about half-way

round the artery, being passed under that part of the sheath held up by the forceps.

The sheath upon the opposite side of the incision should now be taken up with the forceps, and the needle be passed beneath the vessel so as to clear the remaining portion— the deep part—of its surface. The needle will soon emerge in the wound upon the opposite side of the artery, when it should be threaded, and be then withdrawn, carrying the ligature with it.

About one centimetre of the artery more or less is cleared. The needle should be kept throughout at right angles to the line of the vessel. It should rarely be passed threaded.

It is the usual practice to pass the needle from the vein. A more important rule is to pass the needle from the forceps.

It is often more convenient to pass it towards the vein. If the sheath has been well opened, and a way for the ligature carefully cleared around the artery, there can be little excuse for forcing the point of the needle through the sheath into the companion vessel. The aneurysm needle must, of course, be really blunt pointed.

When venæ comites attend a deep artery of moderate size, such as the ulnar or posterior tibial, much time may be wasted and damage done by a determined attempt to separate the artery from the veins. This is especially the case when many transverse connecting branches pass across the artery. In such instances practice has shown that no evil results from including the two veins in the ligature. In dealing with still smaller arteries, such as the lingual, no attempt is made to avoid including the companion veins in the ligature.

It is needless to say that the greatest care must be taken to avoid including a nerve in the ligature. If the sheath be well opened, and the needle be kept close to the artery and be passed round with ease, there is little danger of including a nerve.

If catgut or kangaroo tendon be used, they should have been rendered pliable by a short immersion in sterilised water of a lower temperature than blood-heat.

The ligature should be passed and be tied exactly at right angles to the line of the artery. The knot should be tied quietly and slowly, and not with a vicious jerk.

It should be sufficiently tight to rupture the inner coats. Care should be taken that the vessel is not dragged out of place in the tying.

The points of the two forefingers should meet upon the artery as the knot is being tied, and the final strain upon the ligature should be given by placing the terminal knuckles of these two fingers in contact and using them as the fulcrum of a lever.

The *knot* should be a reef-knot (Fig. 1), not a " granny."
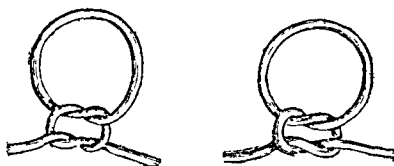
Fig. 1.—The figure to the right shows a reef-knot, that to the left a "granny."

The double-hitch, or surgical knot, is not suitable, more especially when catgut is employed. With this material it may be found to be impossible or very difficult to tighten the knot about the artery. Moreover, the knot when made with catgut forms a considerable mass, and is at the best a clumsy method of occluding the vessel.

The reef-knot, if well tied, will not fail.

CHAPTER II.

Ligature of the Arteries of the Upper Limb.

THE RADIAL ARTERY.

Line of the Artery.—A line from the centre of the bend of the elbow to the gap between the scaphoid bone and the tendons of the extensor ossis and extensor primi internodii pollicis.

Position.—The surgeon stands upon the side to be operated on. The limb is in the position of supination, and is firmly held by an assistant, who grasps it by the hand and by the upper arm.

1. Ligature in the Lower Third of the Forearm.

Operation.—An incision about one inch and a quarter in length is made over the line of the pulse, midway between, and parallel with, the tendons of the supinator longus and flexor carpi radialis muscles. The cut must not reach below the level of the tuberosity of the scaphoid (Fig. 2).

The commencement of the superficial radial vein usually lies over the artery in this situation, and immediately under the skin. It should be avoided.

The fascia, which is here quite thin, is divided in the line of the original wound. The gap between the two tendons is now made manifest. Over, or in close relation to, the artery may be observed the terminal part of the anterior division of the external cutaneous nerve.

It may be impossible to separate the venæ comites from the artery to a sufficient extent to allow the needle to pass. In such case the ligature must include the veins as well as the artery.

2. Ligature in the Middle Third of the Forearm.

Operation.—An incision two inches in length is made in the line of the artery, the limb being in the position indicated. The centre of the incision corresponds to the centre of the forearm (Fig. 2). In cutting through the subcutaneous tissues care must be taken to avoid any superficial vein belonging to the radial or median veins.

The anterior division of the musculo-cutaneous nerve lies usually in the line of the artery, outside the deep fascia and just beneath the superficial veins.

The deep fascia is laid bare, and is divided in the length of the original wound. The fibres are transverse.

The supinator-longus muscle is now exposed about the point where it is beginning to become tendinous. The inner or ulnar border of the muscle is defined, and the muscle itself is drawn outwards. The elbow may be a little flexed to allow of this being done more easily.

The vessel is now found lying upon the insertion of the pronator radii teres, with which it is connected by much connective tissue. The nerve may or may not be seen (Fig. 3).

Fig. 2 —LIGATURE OF THE RADIAL AND ULNAR ARTERIES, AND OF THE BRACHIAL AT THE BEND OF THE ELBOW.

The venæ comites should be separated as well as is possible, and the needle passed from the more convenient side.

B *

Comment.—As the supinator longus is not very wide at this part (especially if the artery be sought for at the lower end of the middle third), it is very easy to expose the outer instead of the inner border of the muscle, in which case the muscle is apt to be drawn inwards, and when the depths of the wound are opened up the radial nerve is reached. This is the common error of beginners.
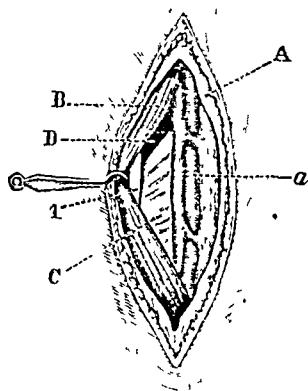
Fig. 3. — LIGATURE OF THE RIGHT RADIAL, ABOUT THE MIDDLE THIRD OF THE FORE-ARM.

A, Fascia; B, Sup. long.; C, Insertion of pron. teres; D, Sup. brevis; *a*, Artery; 1, Radial nerve.

The tendon of the supinator longus as a rule first makes its appearance at the outer border of the muscle, so that if this tendinous edge be exposed the operator will know that he has laid bare the wrong side of the muscle. The inner border of the supinator remains muscular, until it ends somewhat abruptly in the tendon.

3. Ligature in the Upper Third of the Forearm.

Operation.—This operation differs very little from the last. The incision is two and a half inches in length, and is made in the line of the artery. The centre of the skin-cut corresponds with the part of the vessel to be tied. The radial or other surface vein may be encountered in the superficial part of the wound. After the deep fascia has been divided, the interval between the supinator longus and pronator teres muscles is opened up. There is no difficulty in identifying these two structures: the fibres of the supinator are vertical; those of the pronator are oblique. In muscular subjects the supinator is so wide that its inner border cannot be readily exposed.

Under cover of the supinator the radial artery will be found. The nerve is not in relation with it. The

needle should be passed from whichever side is the more convenient.

4. **Ligature of the Radial in the Tabatière Anatomique.** — The radial artery runs over the external lateral ligament of the wrist, just below the styloid process, passes under the extensors of the metacarpal bone and first phalanx of the thumb, and crosses the tabatière. Its course is here represented by a line drawn from the apex of the styloid process of the radius to the posterior angle of the first interosseous space.

The hand is placed upon its ulnar border, and is firmly fixed there by an assistant, who at the same time holds the thumb extended and abducted and the fingers straight.

An incision, about one inch in length, is made along the centre of the tabatière, parallel to the extensor of the metacarpal bone of the thumb, and so placed as to commence at the level of the radial styloid process and lie midway between the extensor ossis and the extensor of the second phalanx of the thumb. The incision will cross the artery a little obliquely. The cephalic vein of the thumb must be avoided. The artery is ligatured in the middle of its course. It will probably be impossible to separate the venæ comites.

THE ULNAR ARTERY.

Line of the Artery. — The ulnar in the lower two-thirds of its course in the forearm is represented by a line drawn from the tip of the internal condyle of the humerus to the radial side of the pisiform bone.

The curve of the vessel in the upper third of its course is such that a line drawn from the commencement of the artery — at the middle of the bend of the elbow — to the radial side of the pisiform bone will scarcely touch the vessel in any part of its course.

The upper third of the artery is too deeply placed to be exposed for ligature, unless it be actually laid bare in a wound.

1. Ligature in the Lower Third of the Forearm.

Operation.—An incision, two inches in length, is made along the line of the artery, just to the radial side of the flexor carpi ulnaris tendon (Fig. 2). The incision terminates an inch or less above the pisiform bone. The deep fascia—which is here very slender—is exposed and divided.

The tendon of the flexor carpi ulnaris muscle is now displayed. The wrist is a little flexed to relax the tendon, which is gently drawn inwards by a blunt hook. The vessels are now exposed. The artery in this situation is bound down to the flexor profundus by a definite layer of fascia. This must be carefully divided. The nerve is close to the artery, and upon its inner side. It may be impossible to isolate the artery from the companion veins. The needle is passed from within outwards. The palmar cutaneous branch of the ulnar nerve lies upon the artery in this situation, and must be avoided.

Comment.—It is possible that the operator may expose the inner side of the flexor carpi ulnaris tendon by mistake. On this (the wrong) side of the tendon muscular fibres will be found entering the tendon almost down to the wrist. On the radial side the tendon is quite clear. Care must be taken not to wound the synovial sac which accompanies the flexor sublimis digitorum tendons beneath the annular ligament. Normally the ulnar gives off no branch in this situation. The posterior carpal arises a little above the pisiform bone.

2. Ligature in the Middle Third of the Forearm.

Operation.—An incision, from two and a half to three inches in length, according to the muscular condition of the limb, is made precisely in the line of the artery (Fig. 2). Beneath the integuments the anterior ulnar vein and branches of the anterior division of the internal cutaneous nerve are apt to be encountered. The deep fascia is thin, and is divided in a line parallel with, but a little to the outer side of the line of, the skin incision.

The surgeon now seeks for the gap between the flexor

carpi ulnaris muscle and the flexor sublimis digitorum
(Fig. 5). The position of this interval is sometimes
indicated by a white line. The gap is, however, best
demonstrated by the touch, the left forefinger being used
for the purpose. As soon as the intermuscular space
has been made evident, the wrist is a little flexed to relax
the muscles. The flexor carpi ulnaris is now drawn in-
wards by means of a broad-
bladed retractor. The flexor
sublimis is in like manner
drawn a little outwards. The
surgeon opens up the vertical
intermuscular space thus de-
monstrated, and at the bottom
of it will probably first be found
the ulnar nerve. To the outer
side of the nerve is the artery
(Fig. 4). The fascia binding
down the vessels in this situa-
tion is slender. There is usually
no difficulty in separating the
artery from its venæ comites.

The needle should be passed
from within outwards, so as to
avoid the nerve.

Fig. 4.—LIGATURE OF RIGH
ULNAR ARTERY AT THE MIDDLE
THIRD OF THE FOREARM.

Deep Wound.—A, Fascia ; B,
Flex. sublimis ; C, Flex. carp.
ulnaris ; D, Flex. profundus ;
a, Artery ; 1, Ulnar nerve.

Comment.—This operation
is associated with considerable
difficulty if carelessly per-
formed, and the procedure is
surrounded by many possibili-
ties of error.

The chief difficulty is to
demonstrate the gap between the flexor carpi ulnaris and
flexor sublimis muscles.

The " white line " which is said to mark this gap is not
to be relied upon. There may be no trace of such a line; it
may be very faintly indicated, or the position of the inter-
space may be marked by a yellow fatty line. The white
line is best seen in young muscular subjects.

The white line, when it does exist, indicates the tendinous margin of the flexor carpi ulnaris. This tendinous tissue belongs to the tendon of origin of the muscle, and not to that of the insertion, as usually stated.   At the level of the centre of the forearm there is seldom any trace of the tendon of insertion.   A faint variety of the white line is sometimes produced by an unusual intermuscular septum.   The flexor carpi ulnaris is much more closely adherent to this septum than is the flexor sublimis, and
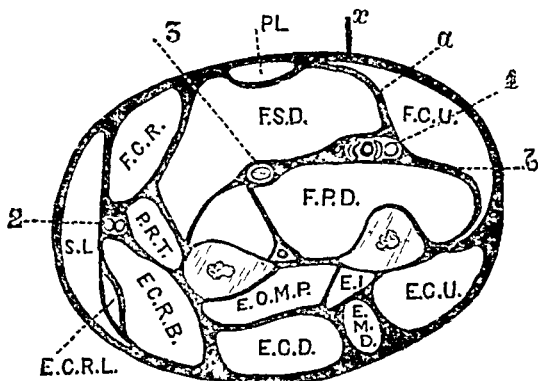
Fig. 5.—TRANSVERSE SECTION OF THE FOREARM (DIAGRAMMATIC), TO SHOW THE INTERMUSCULAR SPACES ABOUT THE MIDDLE THIRD.

Initials indicate the tendons and muscles. *a*, Ulnar artery interspace; *b*, Interspace to be avoided; *x*, the surgical line of the ulnar artery; 1, Ulnar vessels; 2, Radial vessels; 3, Median nerve.

when the fascia is divided the septum adheres to the former muscle, thus producing a species of fascial margin.

The interspace between the two muscles in question is not quite straight, *i.e.* is not quite vertical when the limb is in position for operation.   The flexor carpi ulnaris overlaps the flexor sublimis a little, and the line of the interspace is directed as is shown at *a* in Fig. 5.   The fibres of both the muscles follow the long axis of the limb.

If the division of the deep fascia be exactly in the line of the skin incision, *i.e.* in the line of the artery *x* (Fig. 5), the knife will probably cut upon the flexor carpi ulnaris.

By dividing the fascia a little more to the outer side as advised, the knife comes upon the flexor sublimis (Fig. 5), and by working inwards the oblique gap between the muscles is made out. This gap is always best demonstrated by the finger. It is often indicated by one or more cutaneous arteries which escape here and form an excellent guide to the main artery. The interspace should be sought for at the lower part of the wound, and the separation of the two muscles should take place from below upwards.

In muscular subjects care should be taken that the incision is made long enough.

When the proper interval has been found between the flexor sublimis and the flexor carpi ulnaris, it is not uncommon for the beginner—impressed with erroneous views as to the depths of the artery—to proceed too deeply and too far to the inner side, and actually to pass by the ulnar nerve and open up the interspace between the flexor carpi ulnaris and the flexor profundus digitorum. (*See b,* Fig. 5.)

This may readily happen if the former muscle be dragged too much to the inner side.

THE BRACHIAL ARTERY.

Line of the Artery.—When the arm is extended and abducted with the hand supine, the brachial artery corresponds to a line drawn from the outlet of the axilla (at the junction of its middle and anterior thirds) to the middle of the bend of the elbow.

Position.—In securing the artery at the bend of the elbow, the limb, extended and abducted, may be allowed to rest upon the olecranon. It should not be over-extended.

In dealing with the vessel in the arm, the limb should be extended and abducted, with the hand supine, and should be held away from the body. The arm itself should not be supported in any way, but the limb should be held by the forearm by an assistant.

The surgeon may make the incision from above downwards on both sides of the body, standing to the outer side of the limb on the right side, and between the trunk and

the limb on the left side.   Or on the left side the operator may place himself to the outer side of the limb, and bending over it, may make the incision from below upwards.

1. Ligature at the Bend of the Elbow.

Operation.—The arm having been placed in the position indicated, the surgeon, by flexing and extending the limb, makes out the exact position of the biceps tendon, and by compressing the veins of the upper arm renders evident the median basilic vein.

An incision, two inches in length, is made through the skin, along the inner edge of the biceps and parallel with its margin. The wound will therefore be oblique, and it should be so placed that its centre corresponds to the mark on the skin called the "fold of the elbow." The upper end of the incision will correspond to the level of the tip of the internal condyle. If the veins be normally disposed, the skin wound will lie to the outer side of the median basilic vein, and nearly parallel to it.

Fig. 6.—LIGATURE OF THE RIGHT BRACHIAL AT THE BEND OF THE ELBOW.

A, Fascia ; B, Biceps tendon ; ɔ, Bicipital fascia ; *a*, Artery ; *b*, Venæ comites ; *c*, Basilic vein ; 1, Median nerve.

As soon as the vein is exposed it should be drawn inwards. The bicipital fascia is now demonstrated, and divided in the line of the original incision. Its fibres are directed obliquely downwards and inwards. The artery, with its venæ comites, will now be exposed. The vessel will here be found to be very movable and free from connective tissue attachments, although sometimes surrounded by much fat (Fig. 6, *a*).

The venæ comites having been separated, the needle is passed from within outwards. The median nerve does not come conspicuously into the field of the operation. It is

nearest to the artery (on its inner side) at the upper part of the wound.

Comment.—The median basilic vein is closely attached to the thin integument, and, unless made quite evident, may easily be wounded.

2. Ligature at the Middle of the Arm.

Operation.—The limb having been placed in the position indicated, an incision about two and a half inches in length is made along the inner edge of the biceps muscle, in the line of the artery (Fig. 8).

The fascia, which is here thin, is exposed and divided, and the muscular layer is reached. It is extremely important that the inner margin of the biceps be clearly exposed and surely identified. The muscle is displaced a little outwards, and the pulsation of the vessel is sought for. A little dissection exposes the median nerve —if it be not already in view (Fig. 7). In the middle of the arm the nerve usually lies in front of the artery. In applying a ligature to any part of the brachial, at or above the middle of its course, the nerve should be drawn outwards. If the brachial be exposed below the middle section, the nerve is more conveniently displaced inwards.

Fig. 7.—LIGATURE OF THE RIGHT BRACHIAL AT THE MIDDLE OF THE ARM.

A, Fascia; B, Biceps; C, Triceps; *a*, Artery; *b*, Vena comes; 1, Median nerve; 2, Internal cutaneous nerve.

While the artery is being exposed the elbow may be flexed for a moment.

The sheath of the artery having been opened, and the venæ comites separated as well as possible, the needle is passed from the nerve. The inner of the two companion veins is usually much the larger.

In the upper part of its course the inner margin of the coraco-brachialis muscle is exposed in the place of the biceps, and the ulnar nerve is lying to the inner side of the vessel.

Comment.—This artery is by no means so easy to ligature as may appear ; and in an operative surgery class no more glaring mistakes are made than occur in the course of searching for this superficial vessel.

In the first place, the arm should be unsupported, and be at right angles to the trunk. If the arm be allowed to rest upon a table, the triceps may be pushed forwards, and may be then mistaken for the biceps; while the ulnar nerve has been mistaken for the median. This observation especially applies to the middle third of the limb.

The vessel is mobile, and is easily displaced, and in drawing the biceps aside roughly with a retractor, the vessels and the median nerve have been withdrawn from the field of the operation, and possibly the ulnar nerve brought into view. The clear identification of the biceps margin is essential. The advice sometimes given, that the "sheath of the muscle" should not be opened, is neither sound nor very precise.

The pulse in the brachial is often much feebler than would be imagined ; and this is especially the case in dealing with severe hæmorrhage. The pulsation may be so clearly transmitted to the median nerve that that nerve has been mistaken for the artery.

It is asserted that the basilic vein has been mistaken for the artery. Tillaux states that a large inferior profunda artery has been taken for the brachial.

If the incision be made too much to the inner side of the proper line, the basilic vein may be wounded, especially when it is superficial, *i.e.* in the lower segment of the arm.

In very muscular subjects the biceps may overlap the artery considerably. The frequent abnormalities of the brachial must in all instances be borne in mind.

THE AXILLARY ARTERY.

Line of the Artery.—A line from about the centre of the clavicle to the humerus, close to the inner border of the

.coraco-brachialis, will represent the artery when the arm is so abducted as to be at right angles to the body.

1. Ligature of the Third Part.

Operation.—The patient is placed upon the back, close to the edge of the table, and has the shoulders raised. The arm is at right angles to the body, and is held horizontally.

The surgeon may place himself between the arm and thorax when about to secure either artery.

An incision, about three inches in length, is made along the line of the artery. It commences at the middle of the outlet of the axilla, at the junction of its anterior and
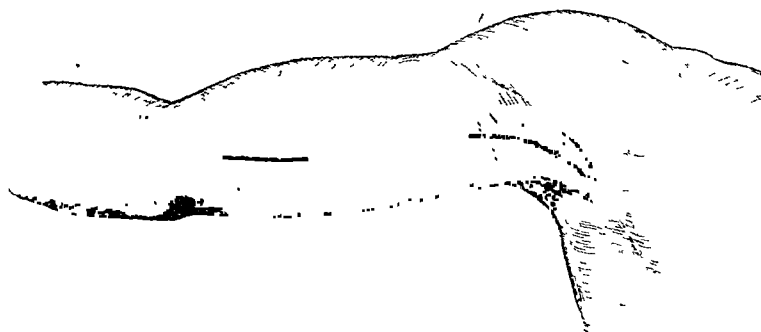
Fig. 8.—LIGATURE OF THE BRACHIAL ABOUT THE MIDDLE OF THE ARM, AND OF THE THIRD PART OF THE AXILLARY.

middle thirds, and is continued down along the inner margin of the coraco-brachialis muscle (Fig. 8). The knife should be held with the blade horizontal. After the integuments and fascia have been divided, the inner margin of the coraco-brachialis should be thoroughly exposed. This muscle, with the musculo-cutaneous nerve, is then drawn gently outwards. The position of the artery may now be determined with the finger. In exposing it the median nerve is at once made evident, and should be drawn outwards by means of a small blunt hook. The internal cutaneous nerve should be gently displaced inwards. The venæ comites need to be well demonstrated. The artery having been cleared, the needle is passed from within outwards (Fig. 9).

Comment.—The numerous nerves in relation with this part of the vessel somewhat confuse the operation. The veins are apt to obscure the vessel. There may be three veins in relation with this part of the axillary—the two venæ comites and the still free basilic. Abnormalities in the artery must be anticipated. A muscular slip, pass-ing from the latissimus dorsi to join the pectoralis major, biceps, or coraco-brachialis, may cross over the vessels. Such a slip may readily be mistaken, when large, for the coraco-brachialis muscle.

The ligature should not be applied too near any one of the branches of the artery.

2. Ligature of the First Part.

Operation. — The patient lies upon the back, close to the margin of the table, with the upper part of the body raised. The point of the shoulder should be carried well back, and to effect this a hard cushion may be placed between the scapulæ. The arm is allowed to lie by the patient's side. It must not be dragged upon so as to depress the point of the shoulder.

The operator should stand upon the outer side of the limb, near the patient's trunk, when dealing with the left side, and near the head when dealing with the right. A good reflected light is ne-cessary.

Fig. 9.—LIGATURE OF THE RIGHT AXILLARY ARTERY (THIRD PART).

A, Fascia; B, Coraco-brachialis; *a*, Artery; *b*, Venæ comites; 1, Median nerve; 2, Int. cu-taneous nerve.

A slightly curved incision, three inches long, with the convexity downwards, is made across the infraclavicular

fossa.   It passes about half an inch below the clavicle, and
the centre of the incision is about opposite to the centre of
that bone (Fig. 10).

The skin, platysma, supraclavicular nerves, and fascia
are divided in the first incision.   At the outer end of the
wound care must be taken not to injure the cephalic vein
and the large branch of the acromio-thoracic artery.

The cephalic vein should be exposed, and forms a
useful guide to the artery.

The outer edge of the pectoralis major is divided
through its entire thickness close to the clavicle, and to the
full extent of the original wound.   The upper edge of the
lesser pectoral should be defined, and may be drawn down
if necessary.

The costo-coracoid membrane must now be dealt with.
It must not be torn through, but should be divided
vertically near to the coracoid process.   The cephalic vein,
if well brought out, will indicate the position of the axillary
vein.   The latter vessel is readily torn in freeing a way
through the costo-coracoid membrane.   The internal
anterior thoracic nerve, coming forwards between the
axillary vein and artery, may, if seen, prove a guide to
the latter vessel, the pulsation of which should, of course,
be felt for.

The artery is now exposed, and the needle should
be passed from the vein.   The vein should be held aside
with the finger while the needle is being passed.

It must be remembered that the vein is least in the way
when the arm is by the side.

Comment.—There is a great danger of tearing the
axillary vein, and also of air being drawn into some of the
smaller veins.   If the pectoralis minor receive a slip from
the second rib, the area of the operation is much curtailed.
The cord or the brachial plexus nearest to the artery may
be mistaken for that vessel.

CHAPTER III.

Ligature of the Arteries of the Head and Neck.

THE SUBCLAVIAN ARTERY.

A ligature has been applied to each of the three parts of the subclavian artery. So far as surgical experience at present extends, it may be said that the operation is rarely justifiable, except in the third part of the artery.

Ligature of the Third Part of the Subclavian Artery.

Position.—The patient lies upon the back, close to the edge of the table, with the thorax raised and the head extended and turned to the opposite side.

The arm should be pulled well down and fixed. This latter object is best effected by passing the arm behind the back, whenever that is possible, and allowing it to remain fixed in that posture. The operator stands in front of the shoulder. A good light is necessary.

Operation.—The skin over the posterior triangle having been drawn down with the fingers of the left hand, an incision is made through it down to the clavicle. By adopting this plan a risk of wounding the external jugular vein is avoided. The incision, which is transverse, should be about three inches in length, and when the traction upon the skin is withdrawn should lie about half an inch above the clavicle (Fig. 10). It should extend across the base of the posterior triangle from the trapezius to the sterno-mastoid, and should be so planned that the centre of the wound shall correspond to a point about one inch to the inner side of the centre of the clavicle. This first incision divides the integuments, the platysma, and the supra-clavicular nerves, with possibly a vein which passes over the clavicle to connect the cephalic vein with the external

jugular. The amount of trapezius and sterno-mastoid exposed will depend upon the extent to which those muscles are attached to the clavicle.

The deep cervical fascia is now reached, and is divided in the length of the original wound No director should be employed. If the surgeon cannot divide the fascia without
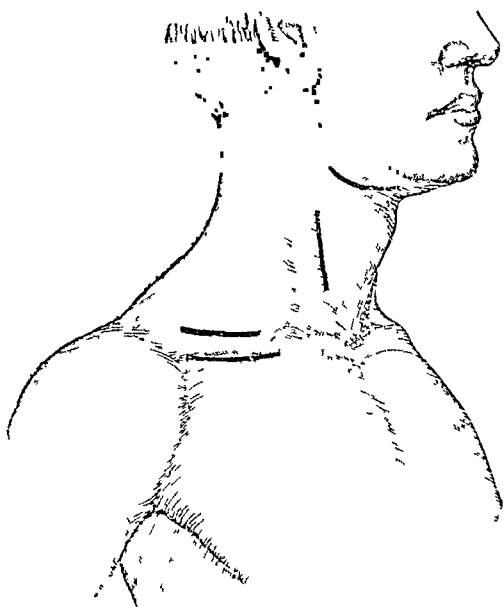
Fig. 10.—LIGATURE OF THE FIRST PART OF THE AXILLARY ARTERY, THE THIRD PART OF THE SUBCLAVIAN, THE COMMON CAROTID, AND THE LINGUAL.

the aid of this dangerous instrument he had better not attempt the operation. The external jugular vein must now be dealt with. Very probably it can be drawn aside and may be held by a small blunt hook towards the outer angle of the wound. If it obstruct the area of the operation in a more determined manner, it may have to be divided between two ligatures. Sometimes when an actual plexus of veins exists in front of the artery much difficulty

is encountered. All bleeding vessels must be secured. The wound throughout should be as bloodless as possible.

The outer margin of the anterior scalene muscle should next be defined, and the position of the omo-hyoid made out. The latter muscle, if at all in the way, must be drawn upwards. When the edge of the scalene muscle has been made plainly evident, the finger should be passed along it until the tubercle on the first rib is encountered. The finger will now be in contact with the artery, and its pulsations can be felt (Fig. 11).
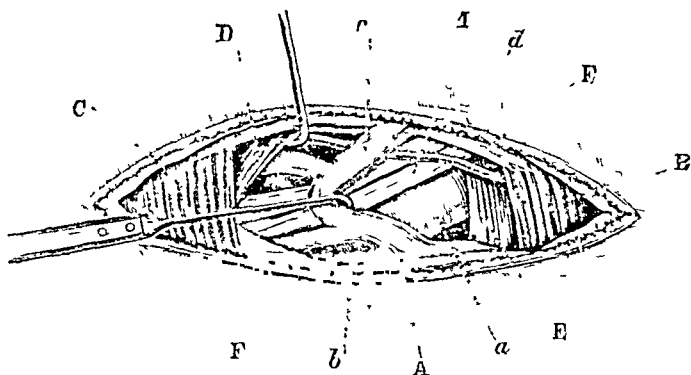
Fig. 11.—LIGATURE OF THE RIGHT SUBCLAVIAN ARTERY (THIRD PART).

A, Clavicle; B, Sterno-mastoid; C, Trapezius; D, Omo-hyoid; E, Anterior scalene; F, Cervical fascia; *a*, Subclavian artery; *b*, Subclavian vein; *c*, Ext. jugular vein; *d*, Transverse cervical artery; 1, Brachial plexus.

The vessel will be found actually resting upon the bone. A little careful dissection will clear the artery and bring into view the lowest cord of the brachial plexus.

This nerve cord should be systematically exposed by a slight and careful dissection. It may be at once said that it has been the source of some of the more serious mistakes which may be made in this operation. The subclavian vein will be seen and felt, but it seldom encroaches much upon the field of the operation.

The transverse cervical artery runs high up, and will probably not come into view. The suprascapular artery

keeps under cover of the clavicle. The fascia surrounding the subclavian is fairly substantial.

The needle (unthreaded) may now be very carefully passed from above downwards and from behind forwards. Its course must be directed by the forefinger of the left hand. By this finger the vein is protected and held out of the way. If the needle be passed from below—*i.e.* from the vein—it is easy to pick up the last cord of the plexus with the artery. The pleura has been wounded by a needle which has been carelessly passed. This accident cannot occur if the needle be passed between the artery and the upper surface of the first rib.

The operation is difficult, and requires a steady hand and perfect control over the scalpel and forceps. The parts should be cautiously exposed by means of the knife and the vivisector's tool, and not by means of tearing and rending with the fingers and blunt instruments.

In order to obtain sufficient room, portions of the trapezius or of the sterno-mastoid may have to be cut.

The transverse cervical or suprascapular arteries may be in the way. They should be drawn aside, but in no case divided, as they play a most important part in the collateral circulation. These arteries have been injured during the operation, as have also been the external jugular vein and the phrenic nerve.

If the neck be short and the patient stout, the difficulties of the operation are much increased. Great difficulty will also be experienced when the veins have a plexiform arrangement or are engorged, and when the tissues are found to be œdematous and matted together.

The pleura has been several times wounded in passing the needle, and in many of the fatal cases where this accident is not noted the patient succumbed to intra-thoracic inflammation. Both Liston and Green passed the ligature around the last cord of the brachial plexus by accident. South has seen the posterior scapular artery picked up and mistaken for the subclavian.

In very few instances does the subclavian vein appear to have been wounded.

Difficulties may be caused by the presence of a cervical rib or by an abnormality in the artery.

Ligature of the Subclavian after Division of the Clavicle.—Of late years it has been proved that division and excision of more or less of the clavicle greatly favours access to the subclavian artery. During the first stage of amputation of the entire upper extremity (Berger's operation) the vein and artery have been thus secured in a great many cases. The excision should be carried out sub-periosteally, and as the aneurysm has probably encroached upon the posterior surface of the bone, great care should be taken not to open into the sac, as if this accident happened it might prevent the operation being completed, and might readily cause fatal hæmorrhage.

THE COMMON CAROTID ARTERY.

Line of the Artery.—The course of the common carotid is represented by a line drawn from the sterno-clavicular articulation to a point midway between the angle of the jaw and the tip of the mastoid process.

A valuable guide to the artery, at about the point of crossing of the omo-hyoid muscle, is afforded by Chassaignac's "carotid tubercle." This is the costal process of the sixth cervical vertebra, and the artery lies directly over it. It is to be found about two and a-half inches above the clavicle.

The common carotid may be secured at any part of its course in the neck. The operations resolve themselves, however, into ligature above the omo-hyoid muscle and ligature below it. The former situation is in every respect to be preferred. Below the muscle the vessel is deeply placed, and has more complicated relations to structures of importance. Farabeuf has well said that "below the omo-hyoid muscle the deaths are more numerous than the recoveries; above, the recoveries preponderate over the deaths."

Position.—The patient lies upon the back, close to the edge of the table, with the shoulders raised and the hand of the affected side placed behind the back. The

chin should be drawn up and the head turned a little to the opposite side. The surgeon stands upon the side exposed for operation.

1. Ligature at the Place of Election (above the Omo-hyoid Muscle).

Operation.—The position of the cricoid cartilage having been defined, and the situation of the super-ficial veins made evident, an incision about three inches in length is made in the line of the artery, and is so placed that its centre is on a level with the cricoid cartilage (Fig. 12).

The skin and platysma having been incised (to-gether with branches of the superficial cervical nerve), the surgeon di-vides the deep fascia along the anterior border of the sterno-mastoid muscle. Along this bor-der a communicating vein between the facial and the anterior jugular may be met with. The edge of the muscle is defined, and is followed until the omo-hyoid muscle is made out. The superior border of this structure must

Fig. 12.—LIGATURE OF THE RIGHT COM. MON CAROTID ABOVE THE OMO-HYOID·

A, Platysma; B, Cervical fascia; C, Sterno-mastoid; D, Omo-hyoid; *a*, Common carotid; *b*, Sterno-mastoid artery; *c*, Middle thyroid vein; *d*, Internal jugular vein.

then be well exposed, and the angle at which the two muscles meet be clearly demonstrated. The sterno-mastoid may be drawn a little outwards, and the omo-hyoid downwards.

The pulsations of the artery should now be sought for, and the vessel can usually be easily detected, as it crosses the conspicuous "carotid tubercle."

The artery is very mobile, and slips readily to and fro under the finger. If the pulse be feeble it may present the physical characters of a flat cord.

In exposing the sheath of the artery, care must be taken to avoid the sterno-mastoid vessel and the superior or middle thyroid veins.

The sheath should be opened upon the inner side, and precaution taken not to damage the descendens noni nerve. Holding the sheaf by the inner lip of the wound which has been made in it, the surgeon, with an unthreaded aneurysm needle, should clear the artery upon its inner side. Holding, then, the outer lip of the sheath in the forceps, the outer side of the vessel can be cleared. By shifting the forceps as required, the whole circumference of the artery can be separated from its sheath. This process must be carried out with great care and with thoroughness.

The needle is passed from without inwards, is then threaded and withdrawn, bringing the ligature with it.

Comment.—In uncomplicated cases the operation is very simple. If the tissues are matted together, or are encroached upon by blood clot, or are displaced by a tumour or growth, the procedure may be attended with no little difficulty and risk.

If the head be turned too much to the opposite side, the sterno-mastoid is carried unduly far over the artery, and the border of the muscle may be missed.

The operation may be much complicated by the presence of large or distended veins. The internal jugular vein is of considerable size, is very thin, and is readily wounded. Its proportions are influenced by the respiratory movements, and, when the breathing is embarrassed, it becomes at one time enormously swollen, and at another moment flat and comparatively small.

Two other veins, though of less importance, may give trouble in the operation. One is the middle thyroid vein, which joins the internal jugular, passing outwards either over or under the artery. The other is a communicating vein between the facial or external jugular and the anterior jugular low down in the neck. It is inconstant, but is some-

times of considerable size, taking the place of the external jugular; as it runs, if present, exactly in the line of the incision, it is sometimes troublesome.

The needle must be passed with great care. The artery has been transfixed by a needle which has been very roughly used. The descendens noni, the pneumo-gastric, and even the sympathetic cord, have been accidentally included in the ligature.

2. Ligature below the Omo-hyoid Muscle.

Operation.—The position of the patient is the same as in the previous operation. The incision is three inches in length, is in the line of the artery, and is so disposed as to commence a little below the level of the cricoid cartilage and end a little above the sterno-clavicular joint. It follows the inner border of the sterno-mastoid muscle. Care must be taken to avoid the communicating vein from the facial, already described, and also the interior jugular vein.

The sterno-mastoid is exposed and drawn outwards. The sterno-hyoid and sterno-thyroid muscles are likewise made evident, and are drawn inwards. The omo-hyoid, if seen, is relegated to the upper part of the wound.

It may be necessary to divide the sternal part of the sterno-mastoid, and the whole or parts of the sterno-hyoid and sterno-thyroid muscles, especially if the ligature has to be applied as low down as possible. Retractors are needed to draw the muscles aside, and a good light is essential.

The inferior thyroid veins may prove very troublesome.

The sheath is opened on its inner side, as already described, and the needle is passed from without inwards.

Comment.—The observations made upon the previous measure apply in the main to the present proceeding.

The depth at which the vessel is placed renders the operation difficult and dangerous, and on the left side the surgeon's movements are apt to be complicated by the position of the internal jugular vein.

The relations of the inferior thyroid artery, and of the recurrent laryngeal nerve, must be borne in mind.

THE EXTERNAL CAROTID ARTERY.

Line of the Artery.—The external carotid is repre-
sented by the upper part of the common carotid line.

Others have proposed a line drawn from the tip of the
lobule of the ear to the
tip of the greater cornu of
the hyoid bone.
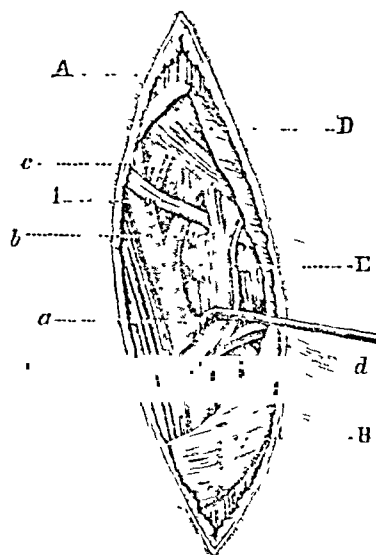
Fig. 13.—LIGATURE OF RIGHT
EXTERNAL CAROTID ARTERY.

A, Platysma ; B, Cervical fascia; C,
Sterno-mastoid; D, Digastric; E,
Great cornu of hyoid bone ; *a*,
External carotid at origin of supe-
rior thyroid; *b*, Crossing lingual
artery points to lingual vein; *c*,
Facial artery; *d*, Facial and supe-
rior thyroid veins ; 1, Hypoglossal
nerve.

Operation. — The posi-
tion of the patient and of
the operator should be the
same as is observed in the
previous operation.

The "place of election"
is represented by the por-
tion of the vessel between
the superior thyroid and
lingual arteries.

An incision, two and a
half to three inches in
length, is made in the line
of the artery from a point
about on a level with the
middle of the thyroid car-
tilage to near the angle of
the jaw. The greater cornu
of the hyoid bone will be
about the centre of the in-
cision.

The integuments and
platysma having been di-
vided, and any superficial
vein secured, the fascia is
cut through, and the an-
terior border of the sterno-
mastoid is exposed in the
lower part of the wound.

This muscle must be drawn outwards   The posterior belly
of the digastric should next be sought for at the upper

angle of the wound, and below it the hypoglossal nerve should be made evident. The surgeon now seeks with the finger for the tip of the great cornu of the hyoid bone, and when this is discovered all the "points" leading to the artery are in evidence (Fig. 13).

The artery should now be exposed opposite to the level of the tip of the great cornu, and between the origins of the superior thyroid and lingual arteries. In this part of the operation care must be taken to avoid the facial and superior thyroid veins. Lymphatic glands may lie in front of the vessel. The artery having been cleared, the needle is passed from without inwards. In effecting this, great care must be taken to avoid the superior laryngeal nerve, which courses behind the artery in this situation.

Comment.—This operation is somewhat difficult, on account of the complicated relations of the artery, and the fact that the branches are not always readily identified.

The artery has been ligatured above the digastric ; but the procedure is still more difficult, and is attended with several special risks.

THE LINGUAL ARTERY.

The artery may be secured in either the first or the second part of its course. In the former situation a ligature is but very rarely applied, the place of election being in the second segmemt of the vessel as it lies beneath the hyo-glossus muscle, and occupies the digastric triangle.

Ligature of the Artery at the "Place of Election," *i.e. beneath the hyo-glossus muscle.*

Position.—The patient lies close to the edge of the table, with the shoulders raised, with the arm of the affected side passed behind the back, and with the face turned to the opposite side. An assistant must keep the chin drawn well upwards and the lower jaw fixed. The surgeon stands upon the side to be operated upon. The chief assistant is placed opposite to him, and leans over the patient's body. A second assistant stands by the surgeon's side. His chief duty is to hold the hook which commands the digastric tendon. The patient must be well anæsthetised

before the operation is commenced. In male subjects the skin of the submaxillary region should be shaved.

Operation.—An incision, some two inches in length, and with the convexity downwards, is made between the lower jaw and the hyoid bone. The wound commences a little below and to the outer side of the symphysis, and ends a little below and to the inner side of the point where the facial artery crosses the lower margin of the maxilla. Its centre is just above the greater cornu of the hyoid bone (Fig. 14). On the right side the incision is made from behind forwards, on the left side from before backwards.

The integuments, platysma, and superficial fascia are divided in the line of the incision. Certain superficial veins will be encountered, and some will probably have to be secured. These veins are the submental or other tributary of the facial, or some tributary of the anterior jugular.

It will now be convenient to apply ligature retractors, in order that the depths of the wound may be well laid open.

The next step is to fully expose the submaxillary gland. It is lodged in a special compartment of the cervical fascia. This fascia should be opened transversely over the lower part of the gland, and the organ should be cleared and brought well out into the wound by means of the finger and the handle of a scalpel. The gland should be turned upwards on to the margin of the jaw, and be kept out of the operation area by means of a broad and well-curved retractor held by the chief assistant.

The fascia exposed by the lifting out of the salivary gland is now to be divided transversely, and in the anterior angle of the wound the posterior edge of the mylo-hyoid muscle must be sought for and defined.

The digastric tendon and the two bellies of the muscle are now to be brought clearly into view. Around the tendon, where it is nearest to the hyoid bone, a small blunt hook with a very long shaft or handle is to be passed and held by the assistant who stands at the surgeon's side. The tendon should be drawn downwards and towards the surface.

By this means the area of the operation is brought well into view, and is increased in extent; the parts are fixed; the hyoid bone, carrying with it the hyo-glossus muscle, is brought nearer to the surface, and the muscle in question is put upon the stretch.

The hyo-glossus muscle can now be easily made out, and its exposed surface freed of connective tissue. The hypo-
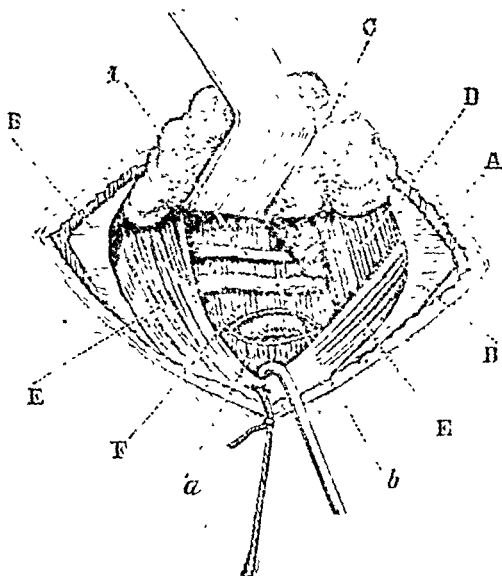
Fig. 14.—LIGATURE OF RIGHT LINGUAL ARTERY.

A, Platysma; B, Cervical fascia; C, Submaxillary gland; D, Mylo-hyoid; E, Digastric; F, Hyo-glossus; a, Lingual artery; b, Ranine vein; 1, Hypoglossal nerve.

glossal nerve must be sought for, as it crosses the muscle, and the surgeon's work be limited to the segment of muscle below the nerve (Fig. 14) in the triangle formed by the hypoglossal above, the digastric behind, and the mylo-hyoid in front.

Crossing the hyo-glossus below the nerve, and parallel with it, is the ranine vein. This vein will about correspond in position with the artery, which lies beneath the muscle.

The vein and the nerve should be displaced upwards.

The hyo-glossus muscle is divided transversely to the extent of about half an inch, a little above the margin of the hyoid bone, and parallel with it.

The incision in the muscular tissue must be cautiously deepened. If the cut has been well placed the artery will bend out into the wound and make itself evident as soon as the whole thickness of the muscle has been divided.

The needle—unthreaded—is most conveniently passed from above downwards. In the ligature the minute venæ comites which attend the artery are no doubt included.

Comment.—This operation requires a good light, and is only performed with ease and certainty when the procedure is carried out step by step.

The stages of the operation should be marked in succession by the following points:—1. The complete lifting up of the submaxillary gland. 2. The demonstration of the edge of the mylo-hyoid muscle. 3. The clearing of the digastric tendon, and the drawing of it outwards with a hook. 4. The demonstration of the hypoglossal nerve on the hyo-glossus muscle.

The incision may be of less dimensions than those given, or may be extended if required.

If the cut be carried too far back, the facial vein and artery are endangered. Time should not be wasted over the early part of the operation. Such veins as are cut may be clamped and left. They seldom require a ligature. The gland must be well exposed. The chief difficulties of the operation depend upon the gland. This gland varies in size, in density, and in the closeness of its attachments. These variations are probably never normal, but are incident to changes connected with cancer of the tongue.

As soon as the gland has been turned out of its bed steps must be taken to keep the wound quite bloodless Other complications are afforded by a matting together of parts by a past inflammation, by the presence of unusual veins, or of enlarged lymphatic glands.

As the wound becomes deep, and the area of the opera-

tion very narrow, a pair of long-bladed and fine dissecting forceps is needed.

The fixing of the digastric tendon and the hyoid bone by means of the small hook is an essential part of the operation. Embarrassed breathing may form a serious complication in the later stages of the procedure.

The hyo-glossus muscle varies in thickness : the part divided is, in the main, the basio-glossus, and the beginner will find the muscle much thicker probably than he had imagined.

The lingual has been cut in dividing the muscle carelessly. The bulging of the artery into the wound in the muscle is very characteristic whenever the incision has been fortunate enough to be accurately placed. I know of no artery which, when exposed by operation, looks less like an artery than the lingual.

CHAPTER IV.

Ligature of the Arteries of the Lower Limb.

The Anterior Tibial Artery.

Line of the Artery.—From a point midway between the head of the fibula and the outer tuberosity of the tibia, to the centre of the front of the ankle-joint.

1. Ligature in the Upper Third of the Leg.

Position.—The patient lies upon the back. The limb is straight upon the table. The foot projects beyond the edge of the table, and is forcibly extended, and (with the leg) fully rotated inwards. The surgeon stands always to the outer side of the limb. The incision for the right artery is made from above down ; for the left, from below up. Two assistants stand on the opposite side of the table—one steadies the leg and manipulates the foot, the other attends to the wound.

Operation.—Before anæsthetising the patient, the outer margin of the tibialis anticus should be, if possible, defined by causing the patient to contract the muscle.

An incision, three and a half inches in length, is made *precisely along the line of the artery (Fig. 15). Its upper* end will be about one inch below the head of the tibia. The deep fascia is exposed, and is divided along the same line. The interval between the tibialis anticus and extensor communis digitorum is made out. The foot is now flexed to relax these muscles. The space between them is opened up by means of the finger and the handle of the scalpel. In doing this, the external border of the tibia is aimed for, and should be distinctly felt before the artery is sought. In proceeding towards this border the extensor communis is held down by the first two fingers of the left hand, while the

assistant holds the tibialis anticus toward the tibia with a retractor. The outer border of the tibia having been made out with the forefinger, the artery will be found to the outer side of it, lying on the interosseous membrane. It is covered and held down by a moderately dense connective tissue. The artery is now exposed, a second retractor being used to repress the extensor communis (Fig. 16).

The venæ comites lie so close to the artery, and in such a position, and send so many transverse branches across it, that it is practically impossible to separate them with certainty. They will be probably enclosed in the ligature. The nerves lie to the outer side of the artery. The needle is passed from without inwards.

The nerve may not be seen. It may not join the artery until the middle third of the limb is reached. It, however, usually meets the vessel at the junction of the upper with the second fourth.

Comment.—The only difficulty in this operation is the finding of the gap between the tibialis anticus and the extensor communis digitorum. Not the least indication of it exists upon the surface of the deep fascia. The "white line" described by some authors is a myth, so far at least

Fig. 15.—LIGATURE OF THE ANTERIOR TIBIAL ARTERY, AND OF THE DORSALIS PEDIS.

as this segment of the limb is concerned. The gap required is to be felt rather than seen.

2. Ligature in the Middle Third of the Leg.

Operation.—The position is the same as in the above operation. Make an incision three inches in length along the line of the artery (Fig. 15). The deep fascia is exposed. The interval between the tibialis anticus and extensor communis is indicated by a yellowish white line. This is due, not to a distinct septum, but to a line of fatty tissue lodged between the two muscles. In emaciated subjects the line may not be apparent. The deep fascia is divided along this line. The two muscles above named are found lying close together. The outer edge of the tibialis anticus is still muscular, but the inner edge of the common extensor is now tendinous.

Flex the foot. Separate the muscles with the handle of the scalpel, keeping in the direction of the tibia. The artery is found upon the interosseous membrane, with the still deeply placed extensor pollicis to its outer side. The nerve will be exposed before the artery is reached, since it here usually lies in front of the vessel. The needle may be passed from either side. It may be impossible to separate the venæ comites, but great care must be taken to avoid the nerve. In the living subject persistent attempts to separate the venæ comites will probably only lead to laceration of those vessels. It is better to tie veins and artery together.

Fig. 16.—LIGATURE OF THE RIGHT ANTERIOR TIBIAL ARTERY (UPPER THIRD).

A, Fascia of leg; B, Tibialis anticus; C, Extensor communis digitorum; *a*, Anterior tibial artery; *b*, Anterior tibial veins; 1, Anterior tibial nerve.

3. **Ligature in the Lower Third of the Leg.**

Operation.—The position is the same, only the foot need not be so much rotated in.

An incision, two to two and a half inches in length, is made in the line of the artery, and just to the outer side of the tendon of the tibialis anticus.

The tendon must be identified beyond doubt before the operation is proceeded with. The deep fascia—here known as the upper band of the anterior annular ligament—is divided in the same line; and the space between the tibialis anticus tendon and the tendon of the extensor pollicis is defined. Both these tendons will be exposed. The artery lies between them, on the front of the tibia, and imbedded in a considerable quantity of fatty connective tissue. The foot is a little flexed, the extensor pollicis tendon is drawn to the outer side by a small blunt hook, and the exposed artery is easily secured.

The nerve lies to the outer side, and the needle should be passed from the nerve. As the vessel is quite superficial, the venæ comites may be separated so as to make room for the needle (Fig. 17).
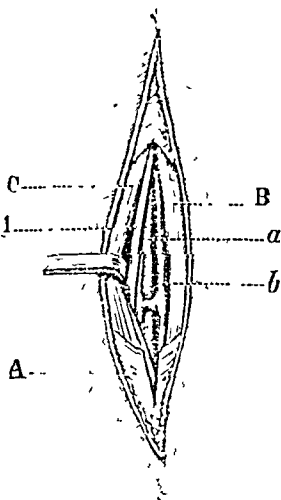
Fig. 17. — LIGATURE OF RIGHT ANTERIOR TIBIAL ARTERY (LOWER THIRD).

A, Anterior annular ligament; B, Tibialis anticus; C, Extensor proprius pollicis; *a*, Anterior tibial artery; *b*, Anterior tibial veins; 1, Anterior tibial nerve.

Comment.—The operation is without difficulty, if one tendon be not mistaken for another. The nerve may lie in front of the artery. The two malleolar arteries—vessels about the size of the posterior auricular—come off just above the ankle-joint.

There are these objections to the operation in this situation: the upper band of the annular ligament is

divided, and the synovial sheath of the tibialis anticus will almost certainly be opened. This is the only synovial sheath on the front of the limb at this level.

Line of the Artery.—A line drawn from the centre of the ham to a point midway between the inner malleolus and the heel will correspond to about the lower half of the artery. The upper half forms a slight curve inward from this line.

1. —Ligature behind the Malleolus.

Position.—The patient lies on the back. The knee is flexed, and the leg lies upon its outer side. The foot lies upon the table also on its outer side, and is secured in that posture by an assistant. The surgeon stands to the outer side of the limb in either instance (right or left limb).

Operation.—A curved incision, two inches in length, is made about half an inch behind and parallel with the margin of the inner malleolus (Fig. 18). The knife is directed towards the tibia. The internal annular ligament is exposed, and divided over the artery. The vessels and the nerve lie in a gap between the tendons that can be appreciated by the touch. The artery having been exposed and separated from the veins, the needle is passed from without inwards.

Fig. 18.—LIGATURE OF THE RIGHT POSTERIOR TIBIAL ARTERY.

Comment.—If the veins are very closely applied about the artery, they may be included in the ligature. In case of high division of the trunk, two vessels will appear, and both will require to be secured. Care must be taken not to
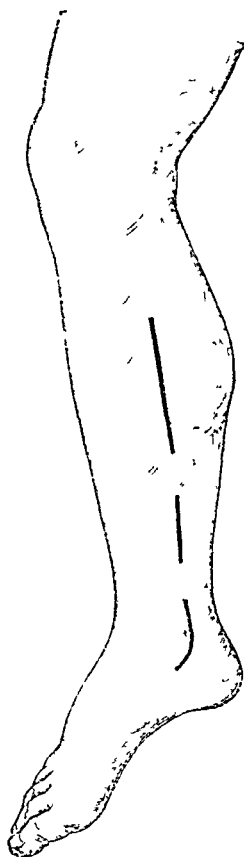
open the sheaths of the adjacent tendons.   The first canal in the annular ligament (that nearest to the malleolus) contains the tibialis posticus tendon; the second contains the tendon of the flexor longus digitorum.   Each of these canals has a separate synovial lining.   Then follows a space wider than that for either of the two named canals, in which are lodged the vessels and nerve. A fourth canal on the astragalus, lined also with a synovial membrane, transmits the flexor longus pollicis tendon.

2. Ligature at the Lower Third of the Leg.

Operation.—The position is the same as in the previous operation.   An incision, two inches in length, is made along the line of the artery midway between the margin of the tendo Achillis and the inner edge of the tibia (Fig. 18).   The superficial and deep fasciæ are divided, together with the upper part of the inner annular ligament.   The artery is found lying on the flexor longus digitorum muscle, with the nerve to its outer side.   The needle is passed from the nerve.   The venæ comites will have to be included if they cannot be readily separated from the artery (Fig. 19).

3. Ligature in the Middle of the Calf.
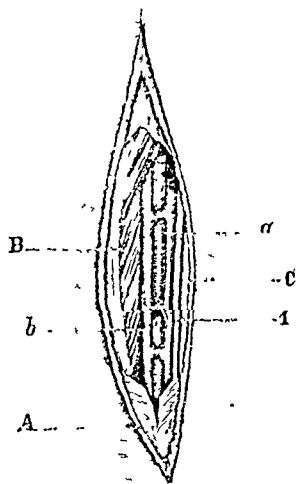
Fig. 19.—LIGATURE OF RIGHT POSTERIOR TIBIAL ARTERY (LOWER THIRD).

A, Fascia of leg (internal annular ligament); B, Flexor longus digitorum and tendon; c, Tendo Achillis; *a*, Posterior tibial artery; *b*, Posterior tibial vein; 1, Posterior tibial nerve.

Operation.—The position is the same as in the preceding operations.   The calf of the leg rests upon the table on its outer side, and the surgeon leans over the limb. The incision is made from above downwards on the right side, and from below upwards on the left.   The assistant,

c*

armed with retractors, stands on the opposite side of the table.

An incision, four inches in length, is made in the middle third of the leg, parallel to the inner margin of the tibia and three-quarters of an inch behind that crest of bone (Fig. 18). The skin having been divided, care must be taken not to wound the internal saphenous vein, which should be drawn aside. The deep fascia—the fibres of which are all transverse—is exposed and divided. In a muscular subject the margin of the gastrocnemius may be seen.

The soleus is now exposed, and must be divided through the length of the incision. The aponeurosis of the muscle is cut through, together with the fleshy fibres attached to it. In making this section the knife should be kept perpendicular to the surface of the muscle. Its edge will therefore be directed towards the tibia, and its blade— in the position in which the limb is held—will be nearly horizontal. When the muscle has been divided, the outer part must be drawn well outwards by a broad retractor or retractors held by an assistant. The deep fascia that covers in the vessels and the deep muscles of the leg is now exposed. If the finger be introduced the vessel can be felt. It must be remembered that the artery lies near the outer border of the tibia. When the fascia has been divided (it is usually very thin) the fleshy fibres of the flexor longus digitorum are exposed. These fibres all run obliquely downwards. By following the surface of the muscle the vessels are reached. The veins are very conspicuous, and may hide the artery. The nerve lies to the outer side, and the needle should be passed from the nerve. It is practically impossible to separate the venæ comites from the vessel.

Comment.—This operation requires a good light, and may be most conveniently done with the aid of a small electric lamp.

The tissues must be carefully retracted, and all the soft parts drawn outwards. In using the retractors roughly, some fibres of the flexor longus digitorum may be torn up and made to hide the artery. This may readily occur in the

cadaver. If in dividing the soleus the knife be not kept towards the tibia, a too extensive division of muscle results, and the wound is unnecessarily deepened.

In identifying muscle it should be remembered that the fibres of the soleus in this situation are attached only along the narrow line formed by the inner margin of the tibia. The surgeon should not lose sight of the fact that the part for which he is aiming is in a line with the outer margin of the tibia.

THE POPLITEAL ARTERY.

The guide to the upper part of the artery is the outer border of the semi-membranosus. The popliteal ends on a level with the lower part of the tubercle of the tibia.

1. **Ligature of the Lower Part of the Artery**
Operation.—The patient is so rolled over as to rest upon the shoulder and one side of the chest, and is indeed made to lie as nearly prone as the circumstances attending the administration of an anæsthetic will permit. The limb is fully extended. The surgeon will stand to the outer side of the left limb and to the inner side of the right. The chief assistant is placed opposite to him. In the case of either extremity the incision is made from above downwards.

A vertical incision—from three to three and a half inches in length—is made over the back of the limb, commencing opposite to the centre of the popliteal space (*i.e.* the level of the knee-joint), and extending downwards over the interval between the two heads of the gastrocnemius muscle.

The skin and superficial fascia having been divided, care must be taken not to damage the short saphenous vein and nerve. These structures will appear at the outer part of the wound, and should be drawn outwards. The deeper fascia is divided in the same vertical line.

The heads of the gastrocnemius muscle are now exposed, and the surgeon follows the interval between them. On each side of this gap a sural artery will be found, accompanied by the nerve to the corresponding head of the muscle.

Deep in the interval itself the large nerve to the soleus muscle (from the internal popliteal) will probably be met with, and must be drawn aside. It usually lies directly in the line of the operation

Following the short saphenous vein, the surgeon is guided to the popliteal vessels. This part of the operation is rendered easier by flexing the knee-joint a little so as. to relax the gastrocnemius. The internal popliteal nerve is first encountered, then the vein and the artery. The two first-named structures are drawn to the inner side. The artery is cleared, and the needle is passed from the inner side (Fig. 20).
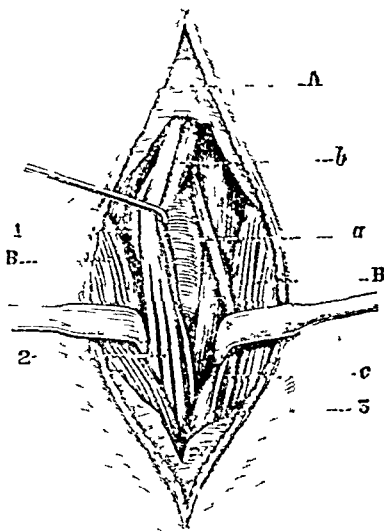
Fig. 20.—LIGATURE OF RIGHT POPLITEAL ARTERY (LOWER PART).

A, Fascia; B, Gastrocnemius; *a*, Popliteal artery; *b*, Popliteal vein; *c*, External saphenous vein; 1, Internal popliteal nerve; 2, Muscular branches; 3, External saphenous nerve.

2. **Ligature of the Upper Part of the Artery.**—This operation is carried out in the thigh. The vessel is secured close to the inner side of the femur, and is reached between the semimembranosus muscle and the tendon of the adductor magnus.

Operation.—The patient lies upon the back, with the hip a little flexed and the thigh fully abducted and rotated outwards. The knee-joint is bent at a right angle, and the knee and leg are thus made to lie upon the outer side.

The surgeon stands to the outer side of the extremity in either case. The incision on the right side is made from

above downwards, and on the left from below upwards. The chief assistant faces the operator.

The incision is three inches in length, is commenced at the junction of the middle and the lower thirds of the thigh, and is parallel with and just posterior to the tendon of the adductor magnus. The position of this tendon should have been well defined.

After the skin has been divided there will probably be found in the subcutaneous fat the anterior division of the internal cutaneous nerve, which lies usually in the direct line of the operation. It should be drawn aside.

The anterior edge of the sartorius muscle is next exposed, and the whole muscle must be displaced backwards.

Upon this muscle at this point will lie the internal saphenous vein. The vessel may possibly be exposed, in which case it is drawn backwards with the sartorius.

The trunk of the internal saphenous nerve is not encountered. It lies beneath the sartorius.

The deep fascia having been well divided, the tendon of the adductor magnus is sought for, and is drawn forwards with a blunt hook. The semimembranosus muscle is next exposed, and is drawn backwards with a retractor. The operator now seeks for the artery in the interval between the two structures. The vessel will be surrounded by much connective tissue, and is lying close to the bone. The internal popliteal nerve is here at some distance from the vessel, and will not be seen. The vein also is not necessarily exposed. It lies posterior to the artery, and to its outer side. Indeed, as approached from this point, the artery is the most superficial of the three structures named.

When the vessel has been properly exposed, the needle may be passed from below upwards.

An aneurysm needle with a large lateral curve will be found the most convenient.

In performing this operation care must be taken not to wound the deep branch of the anastomotica magna artery, which runs along the anterior surface of the adductor magnus tendon.

THE FEMORAL ARTERY.

Line of the Artery.—The hip being a little flexed and the thigh abducted and rotated outwards, a line is drawn from a point midway between the anterior superior spine of the ilium and the symphysis pubis, to the tuberosity of the internal condyle. The centre of Poupart's ligament is entirely to the outer side of the line of the vessels.

The superficial femoral may be ligatured in Hunter's canal or at the apex of Scarpa's triangle. The common femoral may be ligatured at the base of that triangle.

The only one of these three operations which is performed with any degree of frequency is the ligature at the apex of Scarpa's triangle. This is called the " place of election," and in any case in which " ligature of the femoral " is advised or is mentioned, it is assumed that the vessel is secured at this point.

Position.—The patient lies upon the back, with the hip a little flexed, the thigh abducted and rotated outwards, the knee bent and the leg resting upon its external surface.

The surgeon stands to the outer side of the limb in either case, and the chief assistant is placed opposite to him. The incision—in the case of the right thigh—is made from above downwards, and in the case of the left from below upwards.

1. Ligature of the Superficial Femoral in Hunter's Canal.

Operation.—The limb having been placed as already indicated, an incision about three inches in length is made along the line of the artery in the middle third of the thigh.

In the layer of subcutaneous tissue the anterior division of the internal cutaneous nerve will probably be met with, and to the inner side of it the long saphenous vein. This vessel must be drawn inwards.

The fascia lata is now divided in the line of the original wound, and the sartorius is exposed. This muscle must

be clearly identified.   Its fibres run downwards and inwards.

The anterior or outer edge of the muscle having been exposed, the whole structure is drawn inwards with a suitable retractor.

The site of Hunter's canal, lying between the adductor magnus and the vastus internus, can now be well defined, especially if the fibres of the great adductor and the lower border of the adductor longus are made prominent by fully abducting the thigh.

When any fatty tissue which may obscure the part has been cleared away, the fascia which forms the roof of Hunter's canal is rendered distinct.   The fibres forming this fascia are arranged transversely.

At this point there may be exposed, at the outer side of the wound, the nerve to the vastus internus.

The canal is opened in the line of the original wound, and the artery exposed (Fig. 21).

The needle may be passed from either side.

In front and to the outer side of the vessel will be found

Fig. 21.—LIGATURE OF RIGHT FEMORAL ARTERY IN HUNTER'S CANAL.

A, Fascia lata; B, Sartorius; C, Vastus internus; D, Fascia closing in Hunter's canal; E, Sheath of artery; a, Femoral artery; 1, Long saphenous nerve; 2, Anterior branch of internal cutaneous nerve.

the internal saphenous nerve, which is easily avoided.

Care must be taken that the vein be not damaged in passing the needle round the artery.

Comment—The cut is apt to be made too far outwards, in which case the vastus internus is exposed instead of the

sartorius, and the one muscle may be mistaken for the other. Their fibres, however, run in opposite directions, those of the vastus downwards and outwards, those of the sartorius downwards and inwards.

The incision may be made too low down, and the popliteal artery be reached.

In making the skin wound carelessly the internal saphenous vein has been cut into.

The whitish tendon of the adductor magnus has been mistaken for the artery in the dead subject.

Farabeuf recommends that as soon as the sartorius muscle has been drawn aside, the thigh should be well abducted and rotated out, so as to bring into prominence a tendinous cord—*la corde qui vibre*—which is derived from the lower fibres of the adductor longus, and is passing to the general adductor insertion. This cord helps to define the canal, and the incision is made first to its outer side.

2. Ligature of the Superficial Femoral at the Apex of Scarpa's Triangle.

Operation.—The limb is placed in the position already indicated, and the line of the artery is marked out.

An incision, three inches in length, is made along this line as it crosses the apex of Scarpa's triangle. The centre of the wound should correspond to the apex, and the incision, therefore, will reach to within one and a half or two inches of Poupart's ligament.

A large tributary of the internal saphenous vein will usually be exposed, and if it cannot be drawn easily aside it should be divided between two ligatures.

The fascia lata having been divided in the original line, the sartorius is exposed at the outer part and inferior end of the wound, its fibres running downwards and inwards.

Its inner border should be well isolated, and the whole muscle is then drawn outwards.

The operator now feels for the groove of the artery. In front of the vessel will be found branches of the internal cutaneous nerve, and deeper and to its outer side are the long saphenous nerve, and, possibly, the nerve to the vastus internus (Fig. 22).

The sheath of the vessel should be well opened, and the needle passed from the inner side.

Comment.—Scarpa's triangle is much smaller than would appear to be the case when the dissected region is inspected. There may be no more than two inches of the artery left uncovered by the sartorius muscle. An unusually broad sartorius adds a little to the difficulty of the operation.

In order to reach the edge of the sartorius muscle easily, the cut is often made too much to the inner side, with the result that the great saphenous vein is cut into. On the other hand, if the thigh be not placed in proper position, the incision is apt to fall too much to the outer side.

The special danger of the operation consists in the wounding of the vein in passing the needle. The greatest care must be taken to open the sheath of the artery well, and to keep the point of the needle close to the arterial wall.

Fig. 22.—LIGATURE OF RIGHT FEMORAL ARTERY AT APEX OF SCARPA'S TRIANGLE.

A, Fascia lata; B, Sartorius; C, Adductor longus; D, Sheath of artery; *a*, Femoral artery; *b*, Tributary of internal saphenous vein; 1, Long saphenous nerve; 2, Internal cutaneous nerve.

An aneurysm needle, curved laterally, will usually be found the more convenient. Its point should be gently insinuated round the artery.

3. Ligature of the Common Femoral at the Base of Scarpa's Triangle.

Operation.—The position of the surgeon and of the patient has been already indicated. An incision two inches in length is commenced a little above Poupart's ligament (*i.e.* on the abdomen), and is carried downwards parallel with the line of the artery.

In dividing the layer of fatty tissue which covers the fascia lata, care must be taken not to ·injure any of the lymphatic glands of the region, and to avoid the superficial veins, notably the superficial epigastric and superficial circumflex iliac. The cribriform fascia is now divided in the original line, and especial care must be taken not to wound the superficial arteries, the two which usually come nearest to the incision being the superior external pudic and the superficial epigastric.

The crural branch of the genito-crural nerve lies upon the sheath of the artery, but upon the outer side of the vessel.

The sheath being clearly exposed and carefully opened, the needle is passed from the inner side (Fig. 23).

Fig. 23.—LIGATURE OF RIGHT COMMON FEMORAL ARTERY AT THE BASE OF SCARPA'S TRIANGLE.

A, Line of Poupart's ligament; B, Superficial fascia; c, Fascia lata; D, Sheath; *a*, Femoral artery; *b*, Femoral vein; *c*, Internal saphenous vein; 1, Genito crural nerve.

Comment. — By starting from the level of the centre of Poupart's ligament, the incision is placed to the outer side of the line of the vessels, and the vein is thus more certainly avoided. When the vein is at all distended, it is apt to overlap the artery.

CHAPTER V.

LIGATURE OF THE ILIAC ARTERIES—EXTERNAL, COMMON AND INTERNAL.

EXTERNAL ILIAC ARTERY.

Line of the Artery.—A line drawn on the surface of the abdomen from a spot about a finger's breadth to the left of and below the navel, to a point midway between the anterior superior iliac spine and the symphysis pubis. The upper third of this line represents the common iliac, the lower two-thirds the external iliac.

Methods of Approaching the Artery.—The iliac arteries, including the external iliac, can be approached in one of two ways : 1, By opening the abdomen and by directly exposing the vessel. This is called the intraperitoneal method. 2, By means of a lateral incision, which divides all the structures of the abdominal wall with the exception of the peritoneum. The peritoneum is pushed aside, and the artery is reached without opening the serous cavity. This is called the extraperitoneal method.

Of these two methods, the former or intraperitoneal plan is undoubtedly the better in dealing with the common or the internal iliac artery. In ligaturing the external iliac vessel, the two methods are of about equal value, the balance, if any, being in favour of the extraperitoneal measure.

1. The Old or Extraperitoneal Method.

Preparation and Position of the Patient.—The bowels should have been well evacuated, and if there be much flatulent distension of the abdomen, the operation, if not urgent, should be postponed until such complication has been dealt with. The pubic hair should be shaved when the skin is being prepared.

The patient lies upon the back, with the thighs extended and close together. The head and shoulders should be raised, in order to relax the abdominal parietes a little.

The surgeon stands to the outer side of the body in dealing with either artery, and cuts from above downwards on the right side, and from below upwards on the left. His face is towards the patient's face. In slender subjects the left artery might be quite conveniently tied, as the operator stands to the right of the patient's body. The chief assistant is placed opposite to the surgeon, and to him is entrusted the responsible office of using the retractor.

A good broad retractor is needed, together with long dissecting forceps, and an aneurysm needle with a lateral curve. A good light is essential. A reflector will be found convenient, but the most substantial aid is afforded by a portable electric lamp. With such a lamp as this the main difficulties of the operation are removed.

There are two principal methods of exposing the artery extraperitoneally, both of which have been modified beyond recognition, and which are known as Cooper's operation and Abernethy's method.

(1) *Sir Astley Cooper's Operation (Modified).*—The position of the patient has been already indicated. An incision, three and a half inches in length, is made above Poupart's ligament. The cut is commenced about one inch and a quarter to the outer side of the spine of the os pubis, and is placed three-eighths of an inch above Poupart's ligament. For the inner two-thirds of its length it runs parallel with the ligament, but for the outer one-third it curves a little upwards away from the ligament.

The skin and subcutaneous tissues are cut through, and in the latter will be divided the superficial epigastric artery and vein.

The white, glistening aponeurosis of the external oblique muscle is now exposed, and is divided in the line of the skin incision. The knife follows very nearly the direction of its fibres. The parts being retracted, the surgeon seeks for the external border of the conjoined tendon, which will be made out at the inner end of the wound.

The lower fibres of the internal oblique muscle are drawn upwards (Fig. 24), and are divided close to their attachment to Poupart's ligament. The extent of the division corresponds to the extent of muscle tissue exposed in the wound. (The internal oblique is attached to the outer half or two-thirds of Poupart's ligament, the transversalis to the outer third only.)

The fascia transversalis is now exposed, and is divided
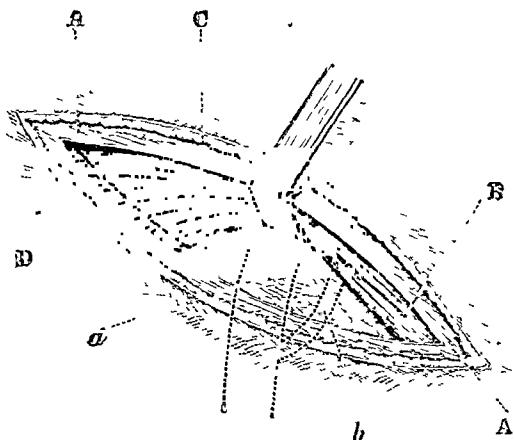
Fig. 24.—LIGATURE OF RIGHT EXTERNAL ILIAC ARTERY.
(*Cooper's Method, modified.*)

A, Aponeurosis of external oblique; B, Conjoined tendon; C, Internal oblique; D, Line of incision in internal oblique muscle; *a*, Position of external iliac artery; *b*, Position of deep epigastric artery.

transversely over the artery, and as far on either side of it as is necessary.

At this stage of the operation care must be taken not to wound the deep epigastric artery, which passes—between the transversalis fascia and the peritoneum—across the wound area.

The external iliac artery can now be made out. The subperitoneal tissue about the vessels should be gently loosened, and the peritoneum then with the utmost care be

peeled from the artery and vein, and pushed upwards in the direction of the umbilicus (Fig. 25).

The fingers alone should be employed in this process. Any form of director is unnecessary and dangerous.

The artery should be bared to such a height as to allow
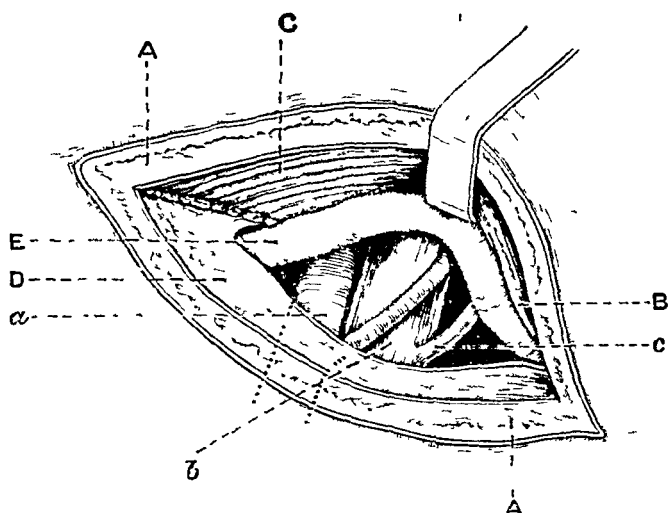
Fig. 25.—LIGATURE OF RIGHT EXTERNAL ILIAC ARTERY.
(*Cooper's Method, modified*)

A, Aponeurosis of external oblique ; B, Conjoined tendon ; C, Internal oblique ; D, Transversalis fascia ; E, Peritoneum ; *a*, External iliac art. ; *b*, External iliac vein ; *c*, Deep epigastric vein.

the ligature to be passed around it at a point one inch and a quarter above Poupart's ligament.

The peritoneum must be kept out of the way with the broad retractor while the artery is being exposed.

The loose subperitoneal tissue which forms a kind of sheath for the artery should be cautiously cleared away.

The needle is passed from within outwards.

After the ligature has been secured, the divided fibres of the internal oblique may be united to Poupart's liga-

ment, and the rent in the external oblique aponeurosis be closed by a few points of buried suture.

No drainage-tube is required.

Comment.—The wound must be of sufficient length, and be carefully placed.

If it be made too low down, there is danger of dividing the circumflex iliac vessels ; if made too high up, of cutting into the internal abdominal ring. If it be carried too far outwards, an unnecessary amount of muscular tissue is divided ; and if too far inwards, the external ring and the structures of the cord may be placed in jeopardy. With care, however, it is easy to displace the cord upwards if necessary.

The tissues must be cleanly divided. The transversalis fascia should be cut sufficiently high to avoid the circumflex iliac vein, but not at too great a height.

Care should be taken not to needlessly tear up the subperitoneal fatty tissue, and infinite care must be taken of the peritoneum. It should not be too extensively stripped up, and in clearing the artery with the finger it is possible to detach the vessel from the psoas muscle. The vein has been damaged in passing the aneurysm needle, and the genito-crural nerve has been included in the ligature.

The peritoneum has been not unfrequently opened. This has resulted sometimes from too high an incision, because the serous membrane becomes more and more intimately connected with the transversalis fascia the farther the distance from Poupart's ligament. The peritoneal cavity has also been often opened up by the incautious use of the steel director (an instrument which should never be employed in this operation), and by a too free manipulation with the handle of the scalpel.

When proper asepsis is being observed, a wound of the peritoneum involves no extra risk. It is simply inconvenient, as it allows omentum or intestine to get in the way. Should the peritoneum be accidentally incised, the best course is to sew up the wound in it with a fine continuous catgut suture, then to push the peritoneal pouch

upwards with finger or small sponge held in forceps, and to continue with the stages of the operation.

The artery should be secured at least one inch and a quarter above Poupart's ligament, in order that the ligature may be well clear of the large branches given off close to the ligament, and a space be allowed for the formation of the necessary clot.

The deep epigastric artery has been accidentally cut during the operation.

(2) *Abernethy's Method.*—The incision is four inches in length, and is commenced one inch and a half above and to the inner side of the anterior superior iliac spine, and is carried down in the direction of the external iliac artery, to a point half an inch above Poupart's ligament. The muscles are divided in order, the peritoneum exposed and pushed back in the manner already described.

Comment and Comparison of the Two Operations.—The comments made upon the previous operation apply, with obvious modifications, to the present method.

Abernethy's operation enables the artery to be ligatured higher up, and the incision is away from the centre of the groin. This is a matter of consequence in dealing with a case of aneurysm involving the upper part of the femoral artery, and possibly encroaching upon Poupart's ligament.

The wound, moreover, is removed from the abdominal rings, and does not concern the deep epigastric artery.

Cooper's operation, however, must be regarded as the better of the two, and it claims that position upon the following grounds :—The operation is easier to perform. The peritoneum is dealt with at a spot where it is but little adherent. It is, in consequence, more readily displaced, and is less exposed to damage.

There is infinitely less division of the muscular structures of the abdominal parietes, the wound is simpler, and the disposition to ventral hernia is less.

The artery is exposed at a great depth in Abernethy's operation, and the wound is so placed that the passage of the aneurysm needle is attended with great difficulty, and with unusual risk of wounding the vein.

The exposure of the deep epigastric artery would appear to be no objection to the operation advised. It is easily avoided.

It has not been shown that any special evils have attended the making of the incision close to the openings of the inguinal canal.

2. **The Intraperitoneal Method.**—The patient is prepared as for an abdominal operation, and all the precautions adopted in such an operation are observed. The patient should be placed in the Trendelenburg position, which causes the intestines to fall away from the artery. The incision is made in the semilunar line close above the groin, and is about three inches in length. Any coils of bowel which may present themselves in the operation area are kept away either by sponges or by a suitable retractor, or by both. As soon as the artery is exposed, the posterior parietal peritoneum which covers the vessel is picked up and is neatly divided directly over the artery and parallel to the long axis of the vessel. Care is taken of the various structures which cross the artery. The needle is passed from the vein.

Care must be taken to avoid the deep epigastric artery in dividing the parietes. This vessel will probably have to be ligatured and divided. The incision in the posterior parietal peritoneum must be free, in order that the artery may be well exposed and the structures in relation with it precisely identified. A good light is needed. Some surgeons suture the divided posterior peritoneum over the artery, but such a measure is not called for.

COMMON ILIAC ARTERY.

The *Line of the Artery* has already been given (page 51).

1. **The Extraperitoneal Operation (Anterior Incision).**—The preparation and position of the patient are the same as have been already described in dealing with the external iliac artery (page 51).

In stripping off the peritoneum the patient should be turned a little upon the sound side, in order that the intestines may be carried away from the wound area.

· The incision on the right side may be made from above downwards, and on the left from below upwards.

A good light is required. Broad spatulæ or retractors are needed, and the surgeon should have provided himself with that form of aneurysm needle which practice of the operation upon the dead body has shown him to be the most convenient. A large, long needle with a lateral curve will probably be found the most convenient.

The incision is about five inches in length. It is commenced one inch and a quarter to the outer side of the spine of the pubes, a little above Poupart's ligament. The first inch and a half of the incision is parallel with Poupart's ligament. The incision is now sharply curved upwards, and ultimately follows a line which is perpendicular to the ligament, and is directed towards a point one inch and a quarter to the outer side of the umbilicus.

The three abdominal muscles are divided, together with the transversalis fascia, and the artery is reached by pushing aside the peritoneum in the manner already described.

Comment.—The general observations made upon the operations for ligaturing the external iliac artery (page 56) apply equally to this procedure. There is great danger of wounding the peritoneum. A very efficient retraction of the soft parts is essential, and the passing of the needle is associated with considerable difficulty.

The operation described is easy, so far as the exposure and separation of the peritoneum are concerned; but the vessel is reached at a great depth, and the passing of the needle is attended with considerable difficulty.

2. **The Intraperitoneal Operation.**—The artery is best reached through the abdominal cavity, and now that the principles of aseptic surgery have rendered the opening of that cavity safe, there is no doubt but that the intraperitoneal operation will replace all others. The abdomen is opened by an incision in the median line, which will be placed between the symphysis and the umbilicus, and will probably have to be extended so as to reach both those points. The Trendelenburg position has

the advantage of keeping the intestines out of the way. Such coils of bowel as present themselves are kept away from the operation area by sponges and retractors.

The peritoneum over the artery is divided by a vertical incision and the vessel well exposed. The needle is best passed from the vein—*i.e.* from right to left in dealing with the left common iliac, and from left to right in dealing with the opposite artery.

INTERNAL ILIAC ARTERY.

1. The Extraperitoneal Operation.—The incision employed is the same as that made to secure the common iliac artery.

The preparation of the patient, the position assumed, and the general features and special dangers of the operations for securing the iliac arteries, have already been dealt with in the sections on the external iliac and the common iliac.

In the present case the peritoneum is pushed aside until the external iliac is reached. The surgeon is guided to the internal artery by following the more superficial trunk. The upper margin of the great sacro-sciatic notch is easily identified, and will serve to indicate the lower end of the artery. The passing of the ligature is difficult, and many aneurysm needles, of various sizes and with various curves, should be at hand. The needle should be passed, on either side of the body, from within out.

2. The Intraperitoneal Operation.—This operation represents the best method of reaching the internal iliac artery, and will no doubt replace the older method just described.

The patient having been placed on the table in the Trendelenburg position, the abdomen is opened in the middle line by an incision extending from the symphysis pubis to the umbilicus, or to a point a little above it. The intestines having been pushed up and drawn aside, the area of the deep wound is surrounded by sponges, and so cut off from the peritoneal cavity.

The peritoneum over the artery is thus well exposed,

and is divided to the extent of one inch and a half. The artery is followed down from the bifurcation of the common iliac. The vein will appear to be about three times the size of the artery, and the separation of the two is a matter of some delicacy. The vein indeed presents the chief difficulty in the operation. Care should be taken that the ureter is not damaged nor accidentally included in the ligature. The many sympathetic nerve fibres which follow the artery may be avoided if the coat of the vessel be well exposed.

A good light, several broad retractors or spatulæ, long dissecting forceps, and a variety of aneurysm needles are required. The operation should be performed with the care which is essential in every abdominal section.

Comment.—The advantages of this method are obvious. The vessel is easily and fully exposed, and the needle can be passed without risk to the vein or the ureter. The operation is simple, and involves but little time. Its dangers are, comparatively speaking, very few. The ligature can be applied accurately at the spot determined upon. The condition of the artery and of the surrounding parts can be made out, and a diagnosis confirmed or modified.

GLUTEAL ARTERY.

Line of the Artery.—If a line be drawn from the posterior superior iliac spine to the top of the great trochanter, when the thigh is rotated in, a point at the junction of the upper with the middle third of that line will correspond to the point at which this branch of the internal iliac artery emerges from the sciatic notch. Another landmark is the centre of a line drawn between the tip of the coccyx and the highest point of the iliac crest. The incision may be made at right angles to this line.

Operation.—The patient is rolled nearly over on to the face; the limb is allowed to hang over the edge of the table ; the thigh is rotated in. The surgeon stands upon the side to be dealt with.

An incision five inches in length is made along the line

just given. The centre of the incision should correspond to the point of exit of the artery.

After dividing the skin and superficial fascia, with a few cutaneous nerves, the gluteus maximus is reached, covered by its fascia. The incision runs parallel with the fibres of the muscle. These fibres are separated in the line of the wound until the thickness of the muscle has been traversed. A muscular branch—from the superficial division of the artery—may here be met with, and will form a guide to the trunk.

The deep fascia between the gluteus muscles is reached, and the contiguous margins of the gluteus medius and pyriformis muscles are exposed.

The gluteus maximus is now relaxed by placing the fully extended thigh upon the table. The interval between the gluteus medius and pyriformis is opened up with retractors, and the upper margin of the sciatic notch defined. The superficial division of the artery passes between the two muscles, and leads the operator's finger to the main trunk. The ligature should be applied as far within the notch as possible—almost within the pelvis— inasmuch as the artery breaks up into its two divisions as soon as it has cleared the notch.

Care must be taken to include neither the nerve nor the vein. In order to obtain a fuller view of the vessel, some fibres of the great sacro-sciatic ligament may require to be divided.

Part II.

OPERATIONS UPON NERVES,

CHAPTER I.

INTRODUCTORY.

THE following are the operations which are considered in this section :—

1. Nerve stretching.
2. Neurotomy, or section of a nerve trunk.
3. Neurectomy, or excision of a portion of a nerve trunk.
4. Neurorraphy, or suture of a divided nerve trunk.

1. **Nerve Stretching.** — This procedure has been applied to nerves of all kinds, both large and small; to motor and sensory nerves, as well as to those of mixed composition.

Nerve trunks are more extensile near the spinal cord than at a distance, and in the upper than in the lower limb. This depends probably upon the strength of the nerve sheath, which is subject to variation, and against which the main strain of the stretching is directed.

The nerve is exposed at its most convenient and usually at its most superficial part, and is then clearly isolated and brought well into view.

In the limbs the joints may be so flexed as to relax the parts about the site of the operation. Good retractors will usually be required. The larger nerve trunks are stretched by means of the finger and thumb, smaller nerves by means of a suitable blunt hook, and the smallest cords with the aid of a fine probe.

The nerve having been replaced, the incision is closed.

2 and 3. **Neurotomy and Neurectomy.**—These operations are of necessity limited to smaller nerves, and in nearly every instance to such nerves as are purely sensory.

The nerve is exposed at some "place of election," and is dealt with by one or other of the methods named.

By means of special forceps (those devised by Professor Thiersch, which resemble long narrow Wells's forceps) several inches of nerve can be dragged out at the time of the neurectomy.

The majority of these operations are not of great gravity.

4. **Neurorraphy.**—This operation concerns the union of nerve trunks which have been severed by accident.

The term "immediate suture" is applied to cases in which the divided ends of the nerve are united within a short time of the accident; the term "secondary suture" to instances in which a period of time varying from weeks to months has elapsed between the receipt of the injury and the operation. It is needless to say that the former measure is the simpler and by far the more successful.

In the *immediate suture*, the wound is perfectly cleaned, the cut ends of the nerve are brought together and united by sutures. Any bruised or jagged part of the exposed nerve is cut away. The general features of the operation are identical with those now to be described.

In the *secondary suture* the steps of the procedure are as follow :

The nerve is exposed. The incision is made over the course of the nerve and parallel to it.

The upper end of the nerve is more easily found than the lower. It is usually enlarged, bulbous, and sensitive.

The lower end, on the other hand, is usually atrophied and filiform, and is apt to be lost in cicatricial tissue, and to be free from notable sensation.

It may be necessary to expose the trunk of the nerve lower down, and then to follow the cord upwards, in order to find the "lower end" with greater certainty.

In any case the operator must be prepared to make a very free wound.

Each portion of the exposed nerve should be freed for some distance respectively upwards and downwards, and the ends carefully drawn up in order to bring as much of the nerve as possible into the wound area to overcome the gap resulting from retraction, and to allow the extremities to be brought readily into contact.

The two exposed ends are excised. This is best done with sharp small scissors. The cut must be clean and quite transverse. The bulb may be cut away layer by layer until a section of healthy nerve fibres is exposed. It is not always necessary to remove the whole of the bulbous end. Indeed, the firmer tissues of the bulb afford an excellent hold for the sutures.

The two ends are united by sutures. From 2 to 6 or 8 sutures will be required, according to the size of the *divided nerve. The material should be either fine silk* or kangaroo tendon. The thread is passed by means of a curved needle. A small "intestinal" needle answers admirably. The needle should be introduced about a quarter of an inch from the free end of the nerve, and the thread should be carried through the whole thickness of the trunk.

All rough handling of the nerve must be avoided.

Finally, the wound is closed.

CHAPTER II.

OPERATIONS UPON THE NERVES OF THE HEAD AND NECK.

FIRST DIVISION OF THE TRIFACIAL NERVE.

The Supra-Orbital Nerve.—The eyebrow is steadied by the operator's left hand while an assistant draws the eyelid downwards. An incision about three-quarters of an inch in length is made horizontally along the superior orbital margin in such a way that its centre will correspond to the supra-orbital notch. The integuments and orbicularis muscle having been cut through, the nerve is readily exposed. The vessels should be avoided.

A vertical incision exposes more of the nerve, and is simpler, but it makes a more considerable section of the muscle and leaves a larger scar.

SECOND DIVISION OF THE TRIFACIAL NERVE.

The Infra-Orbital Nerve.—This nerve may be exposed as it leaves the infra-orbital foramen by means of a transverse incision three-quarters of an inch in length made about a quarter of an inch below the lower margin of the orbit, and so placed as to cross the infra-orbital foramen.

After the skin, layer of subcutaneous fat, and orbicularis muscle have been divided, the levator labii superioris is exposed, and must be severed in the line of the original wound. The nerve is now reached, and can be dealt with. The parts are vascular, and the view of the nerve is apt to be occluded by free bleeding.

Section of the nerve at this spot cuts off merely the terminal branches to the face.

Various methods have been devised for dealing with the

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infra-orbital nerve nearer to its commencement by exposing it through the floor of the orbit.

An incision is made along or near the lower margin of the orbit, the orbital fascia is divided, and the contents of the cavity are displaced upwards by means of a thin spatula.

The infra-orbital groove is exposed, and the nerve divided as far back as possible. If the terminal part has been brought into view through the skin incision, a considerable part of the nerve might be drawn out after the division.

The Trunk of the Superior Maxillary Nerve and Meckel's Ganglion.—A V-shaped incision is made on the front of the cheek, so placed that the apex points directly downwards and the centre of the V is opposite to the infra-orbital foramen. The incision should form two sides of an equilateral triangle, each limb of which measures a little more than one inch.

The knife is carried at once down to the bone, and the triangular flap formed by the soft parts is turned up over the lower lid. A long silk suture is introduced into the apex of the flap, in order that it may be drawn well upwards out of the surgeon's way.

The infra-orbital nerve is sought for and isolated as it is emerging from the foramen. The bone having been cleared, a portion of the anterior wall of the antrum measuring from $\frac{1}{2}$ to $\frac{3}{4}$ of an inch square is removed with a chisel and mallet. The infra-orbital foramen will be a little above the centre of the part removed. The mucous lining of the antrum having been divided, that cavity is fully opened.

The posterior wall of the antrum is now exposed, and a portion about $\frac{1}{4}$ of an inch square is cut away with a fine chisel and mallet.

The next step consists in dividing the mucous lining on the roof of the antrum, under the course of the infra-orbital canal. The bone forming the floor of this canal must be broken away from one end of the maxilla to the other. This is best effected by means of scissors, aided by a fine bradawl and a slender bone elevator or stout director. The

bone is thin and offers little resistance, and the nerve, which must be most carefully preserved and carefully followed line by line, forms the guide to the surgeon's movements. When the posterior wall of the maxilla is reached, the white and conspicuous nerve will be hanging loose in the cavity of the antrum. Slender dissecting forceps with long blades are needed during this stage, and become still more necessary when the region of the foramen rotundum is reached.

The bone of the hinder wall of the antrum must be so completely removed that the nerve is seen to hang free in the cavity produced.

By means of the long slender forceps and a director the surgeon endeavours to make out the position of the trunk as it issues from the foramen rotundum, and, if possible, the precise locality of the ganglion. In this attempt he is aided by the infra-orbital nerve, upon which traction (by means of a silk thread) is maintained. Finally the superior max-
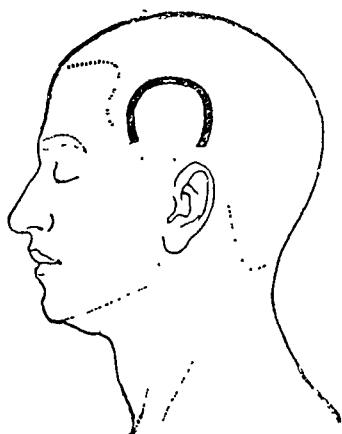
Fig. 26.—OUTLINE OF FLAP TO BE TURNED DOWN IN EXPOSING THE GASSERIAN GANGLION OR THE SUPERIOR MAXILLARY TRUNK.

illary nerve is divided close to the foramen rotundum by a pair of very slender curved scissors, and any branches which still hold the nerve in position having been divided, the whole trunk is removed with the ganglion attached.

The nerve cord removed should measure not less than one inch and three-quarters.

The antrum having been sponged out, the skin incision is united by sutures and the selected dressing applied.

Intracranial Resection of the Superior Maxillary Nerve.—The main steps of this operation are identical with those for excision of the Gasserian ganglion (see

page 70). After the dura mater has been reflected from the bone forming the floor of the middle fossa, the front part of the Gasserian ganglion is exposed, and the superior maxillary trunk defined to its point of exit through the foramen rotundum. The nerve is then excised with a fine knife, a portion from one-third to half an inch long being removed. It is unnecessary to tie the middle meningeal artery during this operation, which is a more complete and certain procedure than any kind of neurectomy performed on the branches of the superior maxillary division.

The Trunk of the Inferior Maxillary Nerve at the Foramen Ovale.—A square vertical flap is cut from the cheek. The two sides of the flap are represented by two vertical lines which are parallel with the anterior and posterior borders of the ascending ramus of the jaw. The base of the flap is represented by a transverse line joining the two vertical incisions about half way down on the ramus of the jaw. The free end of the flap is a little above the zygoma. The incisions are carried down to the bone at the free end of the flap. The zygomatic arch is exposed and its two ends are sawn through. The piece of bone is turned down, together with the masseter attached to it and the soft parts covering the upper part of the ramus of the jaw.

Care must be taken not to damage the facial nerve nor the parotid duct, both of which are below the base of the flap. The flap is drawn forcibly downwards rather than dissected up. After the bleeding has been arrested the coronoid process is divided, and with the attached temporal muscle is turned upwards. The upper head of the external pterygoid muscle is separated from its attachment to the sphenoid, and the nerve can now be exposed and divided with scissors. In the living subject the procedure is a very difficult one.

The Inferior Dental Nerve.—*Neurectomy of the Inferior Dental Nerve through a Trephine Aperture in the Lower Jaw.*—The point of bone to be aimed at is indicated on the ascending ramus by the meeting of two lines—one perpendicular to the lower border of the jaw passing

upwards from its angle, the other a continuation backwards of the alveolar margin (Fig. 27). This point on the side of the cheek is well below the parotid duct and behind the facial vein; the skin incision of one inch should be mainly horizontal, to avoid injury to the facial nerve, but it is convenient to curve it slightly. The masseter being exposed, its fibres are partly severed, but chiefly separated, until the bone is reached and bared with a periosteal elevator.

The pin of a small (half-inch) trephine is then inserted exactly at the spot above-mentioned, and when the outer table of compact bone is traversed the disc is removed by means of the elevator. It is almost certain that the groove containing the inferior dental nerve and vessels will be opened thereby, and it should very carefully be cleared on either side with a small chisel or bone-cutting forceps. The groove should be followed upwards and downwards, with due caution not to injure the inferior dental artery, until the nerve can be raised alone on a hook. With Thiersch's forceps a long piece of both ends of the divided nerve can sometimes be drawn out; if not, as much should be cut away as possible. The bone disc need not be replaced, and two or three fine sutures will suffice for the wound, which heals rapidly.

The success of the operation depends chiefly on exactly following the landmark given, and avoiding injury to the companion artery. As a rule, the dental nerve lies just in front of the latter, and is readily distinguished, once the canal is opened, by its whiter colour.

The Gustatory Nerve.—The mouth having been opened and the cheek drawn aside, the tongue is drawn forward and towards the opposite side.

With the forefinger the surgeon can define the ramus of the jaw and the pterygo-maxillary ligament. The nerve can usually be felt beneath the mucous membrane behind the last-named ligament, and about half an inch behind and below the last molar tooth.

A vertical incision, about an inch in length, is made through the mucous membrane over the nerve, and there-

foie midway between the tongue and the gum, and at the level of the last molar.

The nerve is exposed, is diawn forwards by means of a small blunt hook, and some half inch is excised.

EXCISION OF THE GASSERIAN GANGLION.

It is essential to have a special broad elevator, made of flexible metal and mounted on a short handle, for lifting up
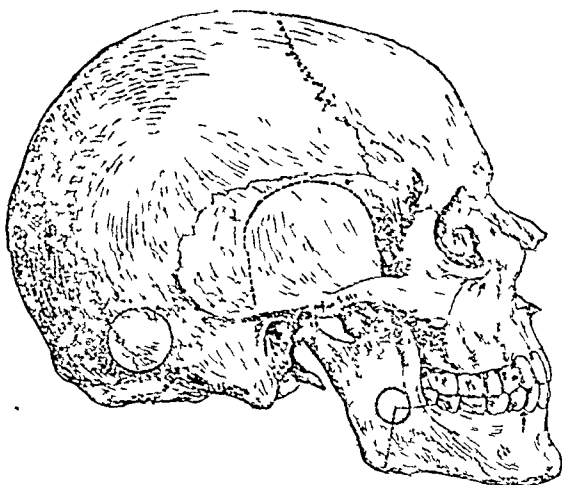
Fig. 27.—OPERATION OF EXPOSING THE GASSERIAN GANGLION.

The area of bone forming the temporal fossa necessary to be removed in oider to expose the Gasseiian ganglion is shown by the dotted line. The skin incision coiresponds, but is somewhat laiger. The two ciicles mark the tiephine apeituies for exposing the bend of the lateial sinus and the inferioi dental neive iespectively.

the dura mater and brain. As it may be necessary to ligatuie the meningeal artery, an aneurysm needle with a short curve, and of smaller dimensions than usual, should be at hand.

The base of the flap to be turned down corresponds to the upper border of the zygoma, its posterior edge to the back of the eminentia articularis. There is never any

need to divide the zygoma in the operation. When the cranial cavity has been opened, the foramen ovale is the first point to be made for. The foramen spinosum (transmitting the middle meningeal artery) is, however, placed externally to as well as slightly behind the larger foramen, and will therefore probably be reached first. A sufficient landmark for the two is the eminentia articularis on the zygoma, which is situated on the same vertical plane, 3 cm. externally to and slightly below them. When
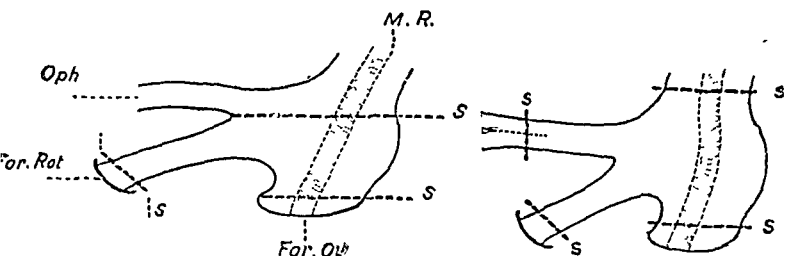
Fig. 28.—DIAGRAM OF THE GASSERIAN GANGLION.

The dotted tract M.R. is the motor root; Oph., the Ophthalmic Trunk; For. Rot., the aperture in the bone for the Superior Maxillary; and For. Ov., the Foramen Ovale, through which the Inferior Maxillary Division passes. The dotted lines S.S., in the right-hand figure, indicate the lines of section where the entire ganglion is removed; those in the left-hand figure S.S., the ones made for the modified excision.

the foramen ovale has been clearly defined, the foramen rotundum must be sought for 2 cm. in front of it.

The Operation.—A rounded flap, including all the tissues down to the bone, is cut with its base at the zygoma and its upper edge two inches above this ridge. (Figs. 26 and 27.) This flap lies over the front half of the squamous portion of the temporal bone, and the incision divides the branches of the temporal artery, which are at once secured by forceps. By means of a large trephine and cutting forceps the corresponding part of the cranial wall is removed, care being taken not to wound the dura mater or the meningeal vessels running in it. The dura mater is now lifted upwards by an elevator from the floor of the middle fossa, working

directly inwards towards the foramen ovale and foramen rotundum, which are situated at a depth of about 3 cm. or $1\frac{1}{4}$ inches from the wall of the temporal fossa. Sufficient bone must be removed to allow of the introduction of the broad bent spatula or elevator by which the assistant raises the temporo-sphenoidal lobe in its case of dura mater. The inferior maxillary nerve must be clearly defined as it passes through the foramen ovale, and at this point the middle meningeal artery may be so much in the way as to require division.

If the meningeal artery has to be tied, double ligatures of fine silk should be used, and the vessel divided between them ; it then becomes easy to expose the inferior maxillary nerve and the lower edge of the ganglion. Working forwards for a distance of about half an inch, the foramen rotundum is reached, and the two main divisions of the fifth nerve are thus exposed. By blunt dissection (the dura mater is thin here and closely adherent) the upper surface of the ganglion is denuded. The inferior and superior maxillary nerves are now cut across, just as they enter the foramina ovale and rotundum. The ganglion is now free at its lower border ; it is gently isolated and drawn forward with fine serrated forceps, and its roots are divided (Fig. 28). A small drainage-tube is inserted and the flap sutured in place. It is unnecessary to put back any bone.

The aperture left by trephining becomes so completely filled up with bone in a year or two that it can no longer be detected.

THE SPINAL ACCESSORY NERVE.

Operation.—The shoulders are raised, the head is thrown a little back, and the face is turned to the opposite side.

An incision three inches in length is made along the anterior border of the sterno-mastoid muscle, commencing above at the tip of the mastoid process. The skin and superficial tissues having been divided, the anterior border of the muscle is exposed, and the cervical fascia freely opened.

The neck being relaxed a little, the sterno-mastoid is

drawn forcibly backwards by an angular steel retractor. This will serve to put the nerve upon the stretch and to bring it a little nearer to the surface.

On careful examination with the finger the nerve may usually at this stage be felt. The best guide to its position is the conspicuous transverse process of the atlas, since the nerve crosses almost directly over that process of bone. The inferior border of the digastric muscle should be defined, and, passing from beneath the digastric to the sterno-mastoid across the site of the atlantoid process, the nerve can readily be exposed by a little dissection.

CHAPTER III.

Operations upon the Nerves of the Upper and Lower Extremities.

THE MEDIAN NERVE.

Operations.—(*a*) In the arm the nerve can be exposed through such an incision as is employed to secure the brachial artery, *e.g.*, in the middle of the arm.

(*b*) At the wrist it is readily exposed through an incision about one inch and a half in length, which is parallel with the tendon of the flexor carpi radialis and close to its ulnar side. A superficial vein or so may be cut, the fascia is divided, and the nerve can at once be brought into view.

THE ULNAR NERVE.

Operations.—(*a*) Above the centre of the arm the nerve may be exposed by an incision parallel to the line of the brachial artery, and half an inch to the inner side of it. In exposing the nerve care must be taken to avoid injury to the venæ comites of the brachial artery, the nerve of Wrisburg, and the ulnar collateral nerve, all of which are in near association with the trunk sought for.

(*b*) The ulnar nerve is very conveniently exposed just above the internal condyle. The incision should be about one inch and three-quarters in length, and should lie upon the line for the nerve already given. The cut should extend to within about half an inch of the internal condyle. The nerve is found to lie along the back of the internal intermuscular septum with the inferior profunda artery, which is placed to its outer side.

(*c*) Just above the wrist the nerve may be exposed by

means of an incision one inch and a half long, made parallel to the tendon of the flexor carpi ulnaris, and just to its outer side. After the integuments and fascia have been divided the nerve is brought at once into view, the artery lying to its radial side.

THE MUSCULO-SPIRAL NERVE.

Operation.—The nerve is most conveniently exposed at the point at which it gains the outer side of the arm. The elbow is flexed, and the arm carried a little across the patient's thorax.

An incision, from two to two and a half inches in length, is made obliquely across the outer surface of the arm at its lower third.

The centre of the incision is made to correspond to a point midway between the insertion of the deltoid and the external condyle, and its obliquity is so determined that the lower part of the incision will follow the line of the upper border of the supinator longus.

The skin and fascia having been divided, the surgeon with his forefinger seeks for the nerve as it lies close to the bone, piercing the intermuscular septum and about to cross the upper limit of the supinator muscle.

If the fibres of this muscle be exposed, the position of the nerve can be more readily determined.

The supinator muscle may be drawn outwards so as to demonstrate the groove between it and the brachialis anticus. The nerve may be carefully separated from the companion artery and drawn forwards by means of a blunt hook.

THE GREAT SCIATIC NERVE.

Operation.—The nerve is most accessible for stretching if exposed at the lower border of the gluteus maximus muscle, just as it is leaving the hollow between the tuber ischii and the great trochanter. This corresponds to its most superficial part.

The patient should be turned sufficiently over upon the face to enable the buttock to be exposed and the thigh

to be extended. A vertical incision, four inches in length, is then made in the course of the nerve.

The incision should commence over the gluteal fold, and should be exactly opposite to the middle of the interval between the tuber ischii and the great trochanter. If the wound be made nearer to the tuber there is an increased difficulty in displacing the hamstring muscles.

The centre of the incision will about correspond to the free lower margin of the gluteus maximus.

The skin and fascia having been divided, the small sciatic nerve and a few cutaneous arteries will be encountered. The quantity of the subcutaneous fat may be considerable.

The lower border of the gluteus maximus should be clearly exposed as it runs obliquely downwards and outwards.

The edge of this muscle must be drawn upwards by means of a strong and broad retractor.

The finger introduced into the wound will now encounter the hamstring muscles a little below their origin from the tuber ischii. These muscles should all be drawn inwards, their fibres having been first relaxed by bending the knee. They are retained in position by another strong and broad retractor.

The nerve should now be readily discovered and brought into view.

Part III.

AMPUTATIONS.

CHAPTER I.

METHODS OF PERFORMING AMPUTATION.

THE following are the principal procedures in amputation :--

    1. The Circular Method.
    2. The Modified Circular Method.
    3. The Elliptical Method.
    4. The Oval *or* Racket Amputation.
    5. The Amputation by Flaps.

1. The Circular Method.—In this method of am-putation the soft parts are divided by a series of circular cuts, made from the skin down to the bone. The tissues are not divided by one sweep from integument to perios-teum, but by successive cuts, in such a way that the skin and the layers of muscle are severed at different levels.

Two forms of circular amputation are practised at the present day. They are identical in principle, and their differences, such as they are, depend upon anatomical features, and are indeed influenced only by locality.

(*a*) The ordinary circular amputation—the *amputation circulaire infundibuliforme* of the French—is illustrated by an amputation through the arm or thigh. In these parts the bone is more or less evenly surrounded by thick muscles. After each circular cut the soft tissues are allowed to retract, or are retracted, before a second sweep is made with the knife. The result is that the wound becomes funnel-shaped ; the edge of the funnel is formed

by the divided skin; the apex of the funnel, or infundibulum, by the divided bone.

(*b*) The circular amputation *à la manchette* is adapted for parts where the covering of the bones is scanty and is composed of irregular tissues. Such a region is best illustrated by the wrist, where the bones are surrounded by many tendons, and where muscular tissue is scanty and unevenly disposed.

In this method of amputating, the skin and subcutaneous tissues are turned up in the form of a cuff, or *manchette*, and turned back like the cuff of a coat.

The skin is divided, as in the previous operation, by circular incision, and is then, together with the subcutaneous tissues, turned back. The turning back of this cuff is mainly effected by the fingers of the surgeon's left hand. The skin is freed by the knife, which should always be held perpendicular to the surface. The cuff is not *dissected* up. It is gently freed and turned up. If the knife be passed obliquely beneath the skin which has to be everted, it is apt to be needlessly damaged.

The cuff must be even and regular, and of a size previously determined upon.

The soft parts are then divided by a circular sweep, with the knife at the level of the retracted and everted skin.

2. The Modified Circular Method.—Three important modifications need to be described: (*a*) In addition to the circular cut through the integuments, a vertical incision is made to join the original wound. The skin on either side of this vertical cut, and at the points where the cut joins the circle, is then reflected in the form of two imperfect skin flaps.

(*b*) Two vertical incisions are made to join the circular wound. By this use of the knife two square skin flaps can be dissected up, and the muscles, when exposed, can be divided by a circular sweep of the knife.

(*c*) Two very short flaps, of semi-lunar outline and of equal width and length, are dissected up. They are composed simply of the skin and the subcutaneous tissues, and consist

of little more than curved incisions made across opposite surfaces of the limb, each being equal to one-half of the circumference of the limb.

The skin beyond the bases of the little flaps is then retracted as a whole, just as in the usual circular amputation. When the retraction has been carried to a sufficient extent, the muscles are divided by circular incisions in the usual way. This method is illustrated by an amputation of the thigh (page 184).

3. **The Elliptical Method.**—This method occupies an intermediate position between the circular operation and the amputation by a single flap.

The incision in the skin is elliptical or lozenge-shaped (*le mode losangique*). The position and inclination of the ellipse vary according to the site of the amputation, and have to be carefully estimated. The skin and subcutaneous tissues are then retracted, by gliding, as in one amputation at the wrist, or by the turning up of a cuff, as in the disarticulation at the elbow by a posterior ellipse, or by the separation of a definite flap, as in Guyon's supramalleolar amputation.

The muscles are usually divided as in the circular operation. They may be, however, cut in part by transfixion, as in the disarticulation at the elbow-joint by an anterior ellipse.

The elliptical method is well adapted for amputations through certain joints.

4. **The Oval Racket Method.**—The skin incision takes the form of an oval with one end pointed, or of an isosceles triangle rounded at its base. The edges of the resulting wound are united in its long axis. The soft parts beneath the skin are divided down to the bone by cutting from without inwards. This operation is illustrated on a small scale by some amputations at the joints of the fingers and toes.

To obtain a better exposure of a joint without loss of substance, and to afford a better covering for the bone in the upper part of the wound, Malgaigne extended a longitudinal cut from the apex of the oval, producing thus

l'incision en raquette, the longitudinal wound forming the handle of the " racket." This incision is also called by the French *l'incision en croupière,* and in some amputations it certainly more closely conforms to the outline of a crupper than to that of a racket.

The racket, crupper, and T-shaped incisions are best illustrated by disarticulations at the metacarpo-phalangeal and metatarso-phalangeal lines of joints.

Amputation by the racket incision is also illustrated by certain disarticulations at the shoulder and at the hip joints.

5. **The Flap Method.**—Any flap or flaps may be composed of the integuments only, or of the integuments and the subjacent muscular tissue.

In every flap the skin must be cut longer than the muscle tissue. A flap containing too much muscular tissue is unwieldy; it is difficult to adjust, and the muscle is certain to protrude. In endeavouring to bring the edges of the skin together, undue strain is apt to be placed upon the sutures.

A flap composed of skin only is very apt to slough. This tendency is least observed in the integuments about joints, where the vascular supply of the skin is derived from many channels; elsewhere an extensive skin flap is very liable to perish for lack of blood.

In general terms, therefore, it may be said that the best flaps are those which contain muscular tissue, provided always that the skin covering the stumps be longer than the divided muscles which it contains.

Modes of Cutting Flaps.—The methods of fashioning flaps have been already in general terms alluded to. Considered more in detail, and from the point of view of the manipulation of the knife, three methods of cutting flaps may be specified :—

> (*a*) By transfixion.
> (*b*) By cutting from without inwards.
> (*c*) By dissection.

(*a*) In cutting by transfixion, a long knife, equal in length

to one diameter and a half of the limb, is employed. The following is the description of an amputation of the arm by double flaps cut by transfixion as given in Heath's "Operative Surgery":—"The limb being held away from the trunk by an assistant, the operator grasps the biceps, with the brachial vessels and nerves, and entering the point of the knife upwards close below his thumb, passes it in front of the humerus, depressing the point as it appears on the opposite side close to the operator's fingers. With a steady sawing movement, a flap from two to three inches long is cut, with the skin left longer than the muscles. Drawing up the flap with his fingers, the operator passes the knife behind the bone, and cuts a slightly larger flap behind, bringing out the knife abruptly at the last. Both flaps being gently retracted, the knife is swept round the bone, which is then sawn steadily through, the thumb and fingers of the left hand protecting the soft tissues."

By another method the skin incisions may be made by cutting from without inwards, and the exposed muscles be then divided by transfixion. This is illustrated by the amputation of the arm by antero-posterior flaps.

(b) In cutting a flap from without inwards, the outline of the future flap is at first marked out by an incision which concerns only the skin and the subcutaneous tissues. When the skin has retracted, the muscles are divided down to the bone by cutting from without inwards.

For this purpose a small but strong knife is employed, and the edge is directed obliquely towards the bone, so that the muscular tissue shall be cut unevenly, the thinnest section being along the margin of the flap, the thickest at its base.

An illustration of this method is afforded by the disarticulation at the shoulder-joint by an external or deltoid flap.

As the skin is allowed to retract before any muscular tissue is cut, the integument of the stump must of necessity be longer than the contained muscle.

(c) In separating a flap by dissection, the flap is at first marked out by a skin incision, and when the integuments

have sufficiently and evenly retracted, the muscular part of the flap is cut with great care. The knife is passed obliquely through the muscle to the bone, and the soft parts forming the apex of the flap having been completely divided, the rest of the deeper tissues of the flap are very carefully dissected up or peeled off from the bone.

This method is well illustrated by the amputation of the leg at the place of election by a single external flap (p. 168).

The main points to be considered in *the selection of a method* are the following:—

1. The least sacrifice of the healthy tissues of the limb.

2. The providing of a good and permanent covering for the bone.

3. The obtaining of as small a wound area as is consistent with the proper performance of the amputation.

4. *The securing of a good blood supply for the flaps or* tissues which will form the stump.

5. The production of a well-adjusted cicatrix, and one so placed as to be removed from pressure when the stump has healed.

6. The ease with which the bone can be exposed at the saw-line, and the general simplicity of the method.

7. The cutting of the main vessels transversely.

8. The rapidity with which the amputation can be performed.

CHAPTER II.

AMPUTATION OF THE FINGERS AND THUMB.

General Considerations.—The position of the phalangeal joints must be clearly defined.

In performing these operations every care should be taken to remove as little of the digit, and especially of the thumb and index, as possible. The shortest and most ungainly-looking stump of the thumb or of the forefinger may prove to be of the greatest value.

If the thumb or a portion of it be left, it is important that it should have something with which to come into apposition ; and in fulfilling this need the slightest stump of the forefinger is of considerable service. The little and ring fingers are of less importance, provided that the other digits remain; but in cases where the three or the two outer fingers have been removed, the little finger or the ring finger has been capable, in conjunction with the thumb, of performing most valuable and most complex functions.

A hand with nothing left but the stumps of a thumb and of a little finger is more useful than the most elaborate artificial limb.

The bone should always be divided as low down as possible. If only the base of the terminal phalanx can be saved, it will secure for the finger the attachment of the flexor profundus tendon.

Amputation of the second phalanx should be performed through the bone whenever possible. If the upper half, or even the upper third, of the phalanx be left, some portion of the insertion of the flexor sublimis will be saved.

It is sometimes said that a stump formed of the whole or part of the first phalanx alone will be immobile and useless. With regard to the index and little fingers this is

certainly not true, and even in the case of the middle and ring fingers the first phalanx alone will, as a rule, provide a useful and mobile stump.

As the bones of the finger are comparatively large in relation to the surrounding soft parts, the flaps must be cut comparatively long. Thus a single palmar flap should be equal to one diameter and a half of the digit. If unequal dorsal and palmar flaps are cut, the palmar flap should be longer than the diameter of the digit, while the dorsal flap should be about the third of the palmar.

Flaps should be so cut that the cicatrix is removed from pressure. The scar, therefore, should not be on the extremity of the stump nor upon its palmar aspect. In other words, it is upon the dorsum that the scar may most conveniently be placed.

For this reason a single palmar flap or a predominating palmar flap (when two are cut) represents the best method in amputation through the fingers. The stump which results is covered with firm and vascular skin, well able to withstand pressure, and is indued with the remarkable sensibility of the part. A dorsal flap involves a covering for the stump which is thin, ill supplied with blood, little able to withstand pressure, and of slight sensibility.

The fibrous sheaths for the flexor tendons when cut across, as in these operations, form rigid tubes along which pus, if suppuration should ensue, may pass and enter the palm of the hand. The flexor tendons retract after division, but the sheaths do not, so there is provided in the depths of the stump a natural drainage-tube, the remote end of which leads into the palm ; if no suppuration occurs, this hidden channel will produce no evil. It is soon occluded and unable to be harmful. If the stump, however, does suppurate, as may occur after crushes of the fingers, the pus can find its way with great readiness into the rigid patent fibrous tube, and then ensues deep-seated suppuration in the stump and in the palm.

To avoid this serious hindrance to healing, the fibrous sheath should be closed when possible after all amputations of the fingers and thumb in which there is any doubt as to

the securing of a perfect aseptic condition. Over the terminal phalanx, and over the joint between the middle and terminal phalanges, there is no fibrous sheath. In front of the metacarpo-phalangeal joint it is scarcely evident. · Over the first and second (proximal and middle) phalanges, and in front of the joint between these bones, the fibrous sheath is well marked, and appears as a rigid tube when cut across.

As the sheath crosses the metacarpo-phalangeal and first interphalangeal joints, it is adherent to the glenoid ligament, and it may easily be closed by two fine catgut sutures passed vertically, *i.e.* from the dorsal to the palmar wall.

Opposite the shafts of the first and second phalanges, however, there is much difficulty in effecting this closure, since the sheath is united to the periosteum, and that membrane is very thin. In these situations the periosteum should be stripped up a little from the palmar aspect of the bone, and the orifice of the tube secured by two fine sutures passed either vertically or transversely, as may appear the more convenient. This stripping off of periosteum should be effected before the bone is divided.

Instruments required.—Narrow, slender, and strong scalpels, the blades of which should be equal in length to about one diameter and a half of the digit to be removed. (A fine scalpel with a cutting edge one inch in length will serve admirably for most amputations of the fingers. The "finger knife" of the instrument makers is an absurd instrument.) A fine key-hole saw or very small Butcher's saw. Bone forceps. Dissecting and artery forceps. Tapes to hold aside the fingers. Scissors, needles, etc.

Position.—The surgeon sits with the patient's hand before him. The limb should be in the position of prona-tion while dorsal incisions and flaps are being made, and in supination during the fashioning of palmar flaps.

In the oval operation the limb may be kept pronated throughout, and disarticulation is in any case conveniently effected in that position.

The surgeon holds the finger to be removed with his

left hand, placed in the supine position. An assistant is placed opposite to the surgeon. He holds the patient's hand in the required position, and keeps the sound digits out of the way.

AMPUTATION OR DISARTICULATION OF THE PHALANGES OF THE FINGERS.

These operations include amputations through the proximal, middle, or terminal phalanges, and disarticulations at the first or second interphalangeal joints. An
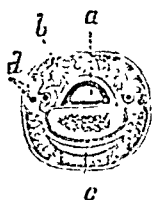
Fig. 29.—HORIZONTAL SECTION THROUGH THE MIDDLE OF THE SECOND PHALANX. (*Tillaux.*)

a, Flexor tendon; *b*, Fibrous sheath of tendon; *c*, Extensor tendon; *d*, Digital artery and nerve.

amputation *through* the terminal phalanx can scarcely claim to be a defined operation.

Two methods will be described—

    1. By single palmar flap.

    2. By unequal dorsal and palmar flaps.

1. By Single Palmar Flap.—Illustrated by the removal of the last phalanx at the joint.

Hold the digit between the left thumb and forefinger (the thumb upon the pulp of the digit, the forefinger on the nail). Ascertain the position of the joint. Commence the incision upon one side of the finger opposite to the joint-line and midway between the dorsal and palmar aspects of the digit. Mark out the palmar flap by an incision which involves the skin only. This flap will include the greater part of the pulp of the finger. Then

carry the incision to the bone throughout, and dissect up the flap so freed, including in it everything down to the bone.

Let the patient's finger be now flexed, and make the dorsal incision. This incision is carried transversely across the finger at the level of the base of the distal phalanx. Retract the soft parts a little and open the joint.

Divide the lateral ligaments. Nothing now connects the phalanx with the rest of the finger but the flexor profundus tendon and the glenoid ligament. Put the terminal phalanx in the position of extreme extension, and divide these two structures by cutting from below up against the base of that phalanx.

2. **By Unequal Dorsal and Palmar Flaps.**—Illustrated by disarticulation at the first interphalangeal joint.

The palmar flap should exceed a little in

Fig. 30.—A and B, Disarticulations by large palmar flap; C, Amputation by unequal dorso-palmar flaps.

length the diameter of the digit at the joint-line. The dorsal flap is one-third the length of the palmar.

Ascertain the line of the articulation.

Hold the finger in the position of pronation, and mark out the flaps by skin incisions. The flaps should be squarely cut. The lateral incisions should be placed midway between the dorsal and palmar surfaces, and should be commenced just above the joint-line.

Carry the lateral cuts to the bone. Flex the finger strongly and carry the dorsal incision to the bone.

Dissect up the dorsal flap, including in it all the soft parts to the bone. Open the joint from the dorsal aspect.

Dissect up the palmar flap, dividing the flexor tendon at the end of the flap while the finger is in the extended position. This flap also includes all the soft parts to the bone.

When the joint is reached, divide the lateral ligaments

separate the glenoid ligament from the base of the second phalanx, and the disarticulation is completed.

The tendon sheath may be closed.

If an attempt is to be made to secure the flexor tendons for reasons already given (p. 83), the divided extremity of each (or the free end of the flexor profundus tendon only) is attached to the remains of the fibrous sheath and to the glenoid ligament (which is left in the stump). The tendons are thus made to occupy the fibrous sheath, which is readily closed around them.

DISARTICULATION OF FINGERS AT THE METACARPO-PHALANGEAL JOINTS.

The following methods will be described :—

    1. By the oval method.
    2. By lateral flaps.
    3. Operations for the forefinger.
    4. Operations for the little finger.

1. By the Oval or **Racket Method.**—The dorsal incision is commenced just above the head of the meta-carpal bone (*i.e.* opposite to its neck), and is carried down in the median line of the finger until it has passed the base of the phalanx.

The cut now divides, and its limbs sweep obliquely across each side of the root of the finger. They are joined on the palmar aspect by a transverse incision, which exactly follows the crease between the finger and the palm, and is therefore level with the free margin of the web.

The surgeon, having made out the position of the joint, holds the finger in the prone position in his left hand. An assistant steadies the hand and keeps the other fingers out of the way.

Throughout the whole operation the limb is kept in the prone position.

The knife is entered upon the dorsum, and is carried first across one side of the root of the finger and then across the other side. The incision is completed by the transverse

palmar cut.   Three separate cuts with the knife are there-fore required.

The incision should at first involve the skin only.

The finger is now extended to its utmost, and the palmar incision is carried to the bone, the flexor tendons being thus stretched and divided.

The finger being then-turned to one or the other side, the lateral incisions—on each aspect of the root of the finger—are carried to the bone. In this way the digital arteries are cleanly divided, and the expansions from the lumbricals and interossei are cut.

The assistant now takes the finger, while the surgeon dissects back the flaps, as far as the joint-line, with the aid of forceps.

The wrist and finger being fully extended, the operator once more takes hold of the digit and proceeds to open the joint from the palmar aspect. He cuts the glenoid ligament transversely against the base of the phalanx, divides the lateral ligaments, and finally completes the operation by cutting the extensor tendon. Disarticulation may be effected from the dorsum, but it renders the section of the glenoid ligament a little less easy.

The synovial sheath for the flexor tendons may be closed.

The glenoid ligament remains in the stump.

The two palmar digital arteries will require to be ligatured or twisted.

The cicatrix is vertical—*i.e.* in the long axis of the limb.

2. **By Lateral Flaps.**—The flaps are of equal size and are a little rounded. The base of each corresponds to the joint-line, the free extremity of each to the level of the web. The median dorsal cut commences just above the metacarpo-phalangeal joint. The palmar median incision extends into the palm up to the level of that joint.

The *modus operandi* is as follows :—

The surgeon marks out both the flaps by skin incisions. He then dissects up one of the flaps (that to the right) until the joint is reached. This flap includes all the soft parts

down to the bone, and the digital artery is divided at its free extremity.

He then opens the joint by cutting the exposed lateral ligament, viz. that to his (the surgeon's) right.

Holding the knife vertically, with the blade directed upwards, the operator passes it across the joint, cuts the opposite lateral ligament, and then fashions the other lateral flap (that to the surgeon's left) by cutting from within outwards.

All the tendons are divided at the joint-level, and are severed as the knife is passed transversely across the articulation.

The digital vessels are cut at the free end of each flap.

3. Modified Operations for the Forefinger.—In order that the cicatrix may not be exposed to pressure when the thumb is opposed to the stump, or when anything is being held in the hand, the following modified procedures may be carried out :—

(*a*) By the racket incision, with the vertical cut placed upon the side of the index nearest to the middle finger, and with the incision carried a little farther on the radial than on the ulnar side of the digit. In the latter situation it corresponds to the web.

(*b*) By unequal lateral flaps, the external flap being the larger.

(*c*) By the externo-palmar flap of Farabeuf. The incision commences at the joint-line, just to the radial side of the extensor tendon. It is carried down along the outer side of the dorsum nearly as far as the centre of the shaft of the phalanx. It is then made to sweep across the palmar aspect of the finger to the web. From the web it passes by the shortest route to the point at which the incision commenced (Fig. 31, A).

The large flap is dissected up, carrying with it all the soft parts down to the bone. The tendons are divided, and disarticulation is effected in the usual way.

4. Modified Operations for the Little Finger.—These have for their object the removal of the cicatrix from an exposed position.

(*a*) By a racket incision, with the vertical cut placed upon the side of the digit nearest to the ring-finger, and with the incision carried a little farther on the ulnar than on the radial side of the finger.

(*b*) By unequal lateral flaps, the internal being the larger.

(*c*) By the interno-palmar flap of Farabeuf. It corresponds to the flap already described as employed for the index finger, with the necessary difference that the position of the incisions is transposed.

Comment.—In all these disarticulations the head of the metacarpal bone should be spared whenever possible.

Of the two operations first described, the better is undoubtedly that by the racket incision.

The operation by lateral flaps has the drawback that the cicatrix is carried into the palm, the tissues of which are opened up.

The method by means of a circular incision at the level of the web, with a median dorsal cut, affords a most excellent covering to the bone, but it provides a somewhat clumsy stump.

AMPUTATIONS AND DISARTICULATIONS OF THE THUMB.

In performing an operation through the first or the second phalanx, or in disarticulating at the interphalangeal joint, one or other of the methods already described may be employed.

The two most suitable operations are the following :—

1. **By the Racket Incision.**—The incision commences upon the dorsum, opposite the neck of the metacarpal bone, and is continued down along the line of the extensor tendon until the base of the first phalanx is passed. Here the incision divides to form the oval, the palmar cut crossing the thumb transversely about opposite to the centre of the shaft of the phalanx.

The steps of the operation have been already described. Disarticulation may be effected from the dorsum.

The two extensor tendons are divided opposite to the

joint line. The flexor longus pollicis tendon may be severed opposite to the palmar incision, and the extremity of the tendon may be attached to the sesamoid bones. The latter structures should be carefully detached from the base of the phalanx, and are left in the stump.
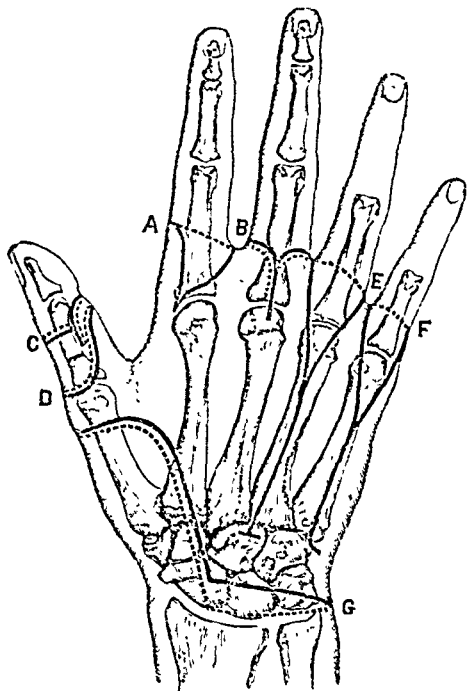
Fig. 31.—A, Disarticulation by special externo-palmar flap; B, Disarticulation by lateral flaps; C, Amputation by unequal dorso-palmar flap; D, Disarticulation by oblique palmar flap; E, Disarticulation of the ring finger, with its metacarpal bone, by racket incision; F, Same operation upon the little finger; G, Dubrueil's disarticulation at the wrist.

The sheath for the long flexor tendon should be closed. Two or more digital vessels will probably require ligatures.

2. **By Oblique Palmar Flap.**—This is Farabeuf's method. It is most excellent in cases where the tissues permit of so large a flap being cut.

The dorsal incision is **U**-shaped, the concavity being towards the nail, and the bend of the **U** opposite to the joint-line.

The palmar incision is **U**-shaped, the convexity being towards the nail, and the bend reaching nearly to the inter-digital fold in the skin.

The lines of the cut follow the lateral borders of the thumb (Fig. 31, D). The flap is dissected up in the usual way. The extensor tendons are divided opposite to the joint, and the long flexor about the middle of the phalanx. The operation is finished in the manner already described.

CHAPTER III.

Amputations of the Fingers and Thumb, together with Portions of the Metacarpus.

Instruments.—A stout narrow scalpel with a blade about $1\frac{1}{2}$ inches long will suffice for the oval methods, and a slender bistoury, with a cutting edge of some $2\frac{1}{2}$ to 3 inches, is required for transfixion operations. A fine keyhole saw. Small retractors. Bone forceps. A rugine, if the periosteum is to be preserved. Dissecting and artery forceps. Scissors, needles, etc.

Position.—The surgeon sits with the patient's hand before him. The limb should be in the position of prona·tion. The operator grasps the finger to be removed, keeping his hand supine. An assistant, placed opposite to the surgeon, holds the patient's hand in the required position, and keeps the sound digits out of the way.

The following procedures will be described :—

1. Partial amputations.
2. Disarticulation of a finger with its metacarpal bone.
3. Disarticulation of the thumb with its metacarpal bone.

1. Partial Amputations.—As much of the metacarpus should be preserved as is possible. In such partial operations the deep palmar arch is not exposed to the risk of being wounded ; the attachments of certain tendons are preserved, the carpo-metacarpal synovial sacs are not opened up, and if the bone be divided beyond its centre the synovial sacs of the flexor tendons may escape the knife in the case of the three middle digits.

The racket method should be employed. The vertical

incision follows the median dorsal line of the metacarpal, while the oval cut traverses the web and follows the transverse digito-palmar crease.

The general features of the operation are the same as in the complete disarticulations (*vide infra*).

The dorsal incision should be commenced a little way above the point at which it is intended to divide the bone.

The bone should be severed with a saw whenever, possible, the soft parts being protected by a director during the passage of the instrument. The shaft is apt to be much crushed if bone forceps are employed.

The second and fifth metacarpals should be divided obliquely, so that the end of the bone may not project unduly upon the margin of the hand.

2. **Disarticulation of a Finger with the corresponding Metacarpal Bone.**—The racket incision is conveniently employed. The operation may be illustrated upon the ring finger (Fig. 31, E). The joint line having been made out, the *queue* of the racket is commenced just above the articulation, and is carried down along the dorsum of the metacarpal until the base of the knuckle is reached.

The incision here divides, and the oval wound, following the clefts between the fingers, crosses the web and terminates transversely at the digito-palmar crease in the skin.

The incision involves at first the skin only, the surgeon holding the finger and manipulating it as required with his left hand.

An assistant now takes charge of the finger while the surgeon deepens the dorsal incision and divides the extensor tendons just beyond the base of the bone.

The sides of the shaft of the metacarpal are now bared from one end to the other, the knife being kept very close to the bone. During this step the surgeon uses his left finger to assist in the separation of the interossei from the shaft, the assistant rotating the digit as required.

The knife is carried back between the bases of the metacarpal bones (on either side of the bone to be removed), so

as to divide the interosseous ligaments; the skin is at the same time retracted, so as to expose the part. To reach the articulation more conveniently, a transverse cut may be made at the end of the vertical incision. (Fig. 31, E.)

The operator now carries the knife forward through the tissues of the web on either side of the finger, and, the digit being fully extended, the palmar incision is carried down to the flexor tendons.

The assistant then holds the finger in the position of the extremest extension, while the surgeon lays bare the under-surface of the flexor tendons, which he ultimately divides opposite the neck of the shaft.

While the finger is still extended to the utmost, the operator exposes the palmar surface of the bone as well as is possible and as far back as is possible.

The ligaments of the joint having been divided, the finger is turned back upon the dorsum of the hand, and the last structures divided are such resisting palmar structures as still remain, together with the tendon of the extensor carpi radialis brevior.

The digital arteries are divided in the tissues of the web.

The synovial sheath of the flexor tendons may be closed with fine catgut sutures, if considered desirable.

In the case of the *index finger* the vertical incision should be carried along the dorsum of the bone rather than along its radial side, as sometimes advised. A transverse cut should be made over the trapezoid at the end of this incision.

In removing the *little finger* with its metacarpal bone, the dorsal incision should be placed rather towards the inner side of the shaft of the bone, and from its extremity a short transverse cut may be made towards the ulnar margin of the hand (Fig. 31, F).

3. **Disarticulation of the Thumb together with its Metacarpal Bone.**—In this operation especial care must be taken not to wound the radial artery as it passes close to the base of the metacarpal bone to reach the palm, and not to open the joint between the metacarpal of the index and the trapezoid.

One of the two following methods may be employed :—

1. *The Racket Method.*—The hand is to be held in the mid-position between pronation and supination. The wrist is steadied by an assistant while the surgeon holds the thumb.

The dorsal incision commences in the *tabatière*, just above the carpo-metacarpal joint, and on the tendon of the extensor primi internodii pollicis. It runs along the dorsum of the thumb, keeping nearer to the external than the internal border of the metacarpal bone.

The oval encircles the head of that bone and crosses the palmar aspect of the digit on a level with the free edge of the web as displayed when the thumb is abducted (Fig. 32).

The procedure is practically the same as that already described for the fingers.

The sheath of the flexor tendon may be closed.

The arteria princeps pollicis, or its two collateral branches, will be found divided on the palmar aspect of the wound, and will require a ligature. The vessel runs along the

Fig. 32. — DISARTICULATION OF THE THUMB WITH ITS META-CARPAL BONE BY A RACKET INCISION.

palmar side of the metacarpal bone, and bifurcates between the heads of the flexor brevis and under cover of the long flexor.

The two dorsal arteries of the thumb are small, and may not require to be secured.

2. *By Palmar Flap.*—This operation may be rapidly performed, but it is decidedly inferior to the method just described.

E

An assistant holds the finger while the surgeon abducts the thumb. The knife, introduced into the centre of the web, passes beneath the muscles of the thumb, and emerges at the base of the metacarpal bone. By cutting outwards a rounded flap is formed, comprising the whole of the tissues of the thenar eminence. The extremities of this flap are now united by a straight dorsal cut, the thumb being still abducted, the remaining soft parts are divided, the joint is opened on the inner side, and the disarticulation completed.

On the left hand the flap may be formed by introducing the knife at the base of the metacarpal bone and bringing it out at the centre of the web.

CHAPTER IV.

Disarticulation at the Wrist-Joint.

Instruments.—A narrow amputating-knife, with a stout handle and a blade from three to four inches in length. A scalpel. Dissecting and artery forceps, scissors, needles, etc.

Position.—The surgeon sits facing the patient's forearm, which is abducted horizontally and with the hand pronated. An assistant stands facing the operator, and with his back to the patient's shoulder. He steadies the limb, draws up the soft parts, and takes charge of the flaps as they are formed. He can also manipulate the hand if required. A second assistant may conveniently attend to the sponging.

The following *methods* of disarticulating will be described :—

1. Circular.
2. By elliptical incision.
3. By long palmar flap.

1. **The Circular Method.**—The circular incision is some way below the joint, and is inclined a little lower down upon the radial than upon the ulnar side, in order that the outer styloid process may be well cleared.

The incision on the inner side is just above the base of the fifth metacarpal bone, while on the outer side it crosses the first metacarpal about 1 cm. below the carpo-metacarpal joint of the thumb (Fig. 33, A).

The surgeon, holding the patient's hand in his left hand, makes the circular incision, commencing it upon the dorsum, and turning the hand from the prone to the supine position as the knife travels round the limb.

The incision concerns at first the skin and the sub-cutaneous tissues only, and as it is being made the assistant draws up the soft parts of the dorsum.

The hand is now allowed to drop into the prone position, while the operator dissects up the integuments of the dorsum until the joint-line is reached and the styloid processes are cleared. The left fingers are used to assist in this retraction.

The surgeon once more grasps the pronated hand, and flexing the wrist to the utmost, divides the left lateral ligament (*i.e.* the ligament on the operator's left).

By continuing the incision transversely, all the extensor tendons are severed opposite the line of the articulation, the joint is opened, and finally the right lateral ligament is cut.

Still flexing the wrist, and so rotating the hand that the border on the surgeon's right is turned well forward, the *operator cuts the anterior ligaments close to the carpus, and* clears the bony eminences at the root of the palm. Unless care be taken, the pisiform bone is very apt to be left behind.

Little now is left but the mass of the flexor tendons. These are dragged upon while the wrist is still forcibly flexed, and the knife having been passed between the carpus and the tendons in question, the limb is finally severed by cutting vigorously from within outwards.

In the final cut the palmar incision is, of course, followed. The wound is united so as to form a transverse cicatrix.

Hæmorrhage.—The radial artery is divided in the dorsal wound at its outer extremity.

At the inner angle of the dorsal wound the carpal branch of the ulnar may be found bleeding.

In the palmar wound are divided the superficial and deep portions of the ulnar artery on the inner side and the superficialis volæ on the outer.

2. **The Elliptical Method.**—So far as the covering of the bones is concerned, this method is nearly equivalent to disarticulation by a palmar flap.

The positions of the patient and of the operator are the same as in the circular method.

The blade of the knife should be four inches in length.

The highest point of the ellipse is on the dorsum, a little to the inner side of the middle line, and half an inch below the line of the wrist-joint.

The lowest point is on the palm, in a line with the middle finger, and about two inches below the level of the highest point.

In forming the ellipse between these two points the incision on the ulnar side should pass between the pisiform bone and the base of the fifth metacarpal, while on the radial side it should cross the carpo-metacarpal joint of the thumb (Fig. 33).

The surgeon, holding the subject's hand in the supine position, marks out the palmar part of the ellipse, commencing the incision on the left side (the surgeon's left) of the hand.
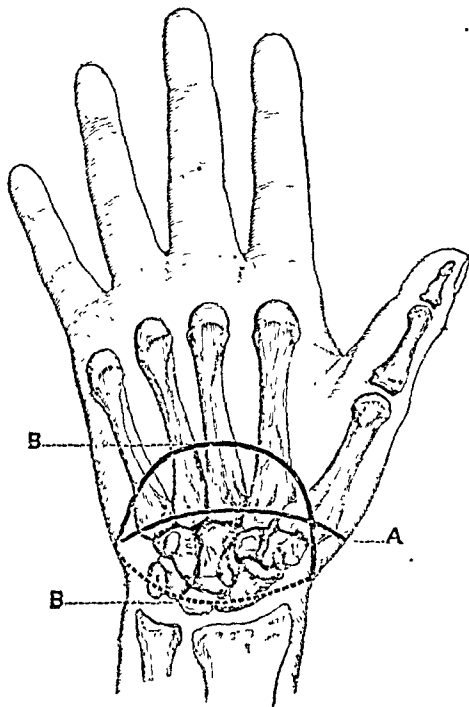

Fig. 33.—A, Palmar incision in the circular disarticulation at the wrist; B B, Incision in the elliptical disarticulation at the wrist.

The operator now pronates the hand and marks out the dorsal segment of the ellipse, the assistant at the same time drawing up the integuments at the back of the hand.

The first incision concerns the skin and the subcutaneous tissues only.

The remaining steps of the operation are nearly identical with those of the circular method.

The integuments on the dorsum are separated up until the styloid processes and the joint-line are cleared.

The surgeon, holding the pronated hand in the position of forced flexion, now divides in order the lateral ligament on the left, the extensor tendons and posterior ligament, and the lateral ligament on the right. The tendons are divided immediately opposite to the articulation, which is thus freely opened.

The anterior ligament is now severed close to the carpus.

The hand, still hanging down in the position of pronation and flexion, is so rotated that one or other border is turned forwards so as to face the surgeon. While in this position the lateral parts of the ellipse are deepened towards the palm, and the two bony eminences at the root of the palm are cleared, the knife being kept close to the bone.

The instrument is held vertically, with its point downwards, and is passed between the mass of the flexor tendons and the hollow of the carpus. With the knife held in this position the "carpal canal" is cleared out.

Nothing now remains but to divide the flexor tendons and the surrounding soft parts. The tendons are dragged upon and are cut obliquely from within outwards, the knife—now held horizontally—finally following the existing cutaneous incision.

When the wound is adjusted, the cicatrix appears as a curved line upon the dorsum.

Hæmorrhage.—The radial artery is cut in disarticulating, and is found divided at the outer extremity of the dorsal wound. It is severed above the origin of the branches to the thumb and index finger.

In the inner portion of the palmar flap the ulnar artery is divided as it is forming the commencement of the superficial palmar arch.

Deeper in this part of the palmar flap the deep branch of the ulnar artery is cut.

In the outer segment of the palmar flap the superficialis volæ will be found severed.

The deep palmar arch and the greater part of the superficial arch are, of course, removed with the hand.

3. **By a Long Palmar Flap.**—The flap is U-shaped. It commences half an inch below the radial styloid process, and ends half an inch below the tip of the corresponding process of the ulna. The outer limb is directed towards the gap between the index and middle fingers, the inner limb towards the web between the little and ring fingers.

The almost transverse extremity of the flap reaches nearly to the middle of the metacarpus. Its general outline is shown in Fig. 34. The dorsal incision is carried straight across the back of the limb from one extremity of the palmar flap to the other. It will therefore cross the carpus.
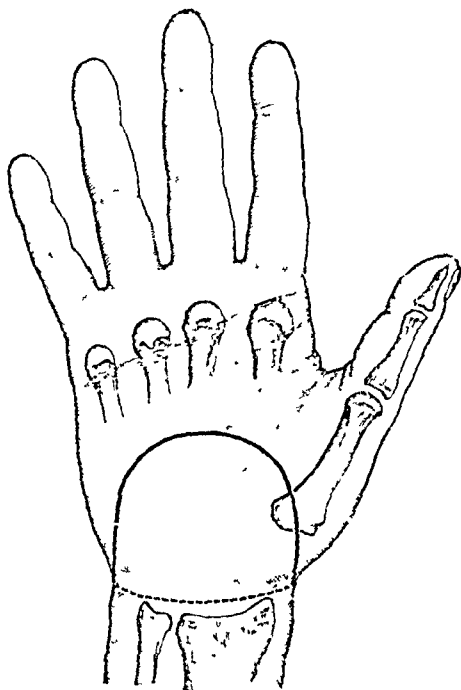
Fig. 34.—DISARTICULATION OF THE WRIST BY LONG PALMAR FLAP.

A stout knife with a blade some three inches in length is required.

The operator grasps the patient's hand and holds it in the position of extension and supination.

Entering the knife half an inch below the styloid process to his left, he carries it across the palm, in the direction indicated, to the corresponding point on the other side of the hand, and thus marks out the palmar flap.

An assistant now takes the hand and retains it in the same position while the operator proceeds to dissect up the great flap. This should include all the soft parts down to the flexor tendons. A considerable portion of the muscles of the thenar and hypothenar eminences will consequently form a part of the flap, and the limb of the superficial palmar arch will be divided at its free end.

The flap should be dissected up to the level of the radio-carpal joint, care being taken to clear the bony prominences in the palm of the hand.

The surgeon now takes the hand and holds it in the pronated position, while the assistant draws up the skin on the back of the limb. The dorsal incision is made. The integuments are dissected up to the joint-line, and the extensor tendons and the ligaments of the wrist are divided precisely as in the previous operation.

Nothing now connects the disarticulated hand with the forearm but the mass of the flexor tendons and the tissues about them.

These are drawn upon and divided by a vigorous transverse cut made from above downwards—*i.e.* from dorsum to palm—care being taken that the palmar flap is held well out of the way at the time.

The palmar flap should never be cut by transfixion. The bony prominences in the palm render such a method difficult, and an unduly scanty flap is apt to result.

Hæmorrhage.— The vessels are divided as in the previous operation. The deep palmar arch and the transverse part of the superficial arch are removed with the hand.

Comment.—Of the operations described, the best procedure is undoubtedly the *elliptical method.* The cicatrix falls upon the dorsum, the bones are well covered, and the free end of the stump is made up of the tough and well-nourished tissues of the palm. The styloid processes are well protected.

The operation by a *palmar flap* may rank next in order of value. It has these disadvantages when compared with the elliptical operation : The tissues of the palm are more extensively encroached upon ; the flap is of a somewhat

awkward shape, and, as it includes the tougher parts of the palmar integuments, it is a little unyielding and stiff, and not so readily adjusted as is the smaller and less rigid flap of the elliptical method.   The flap, moreover, contains more fatty tissue, and healing after the operation is usually a little slow—a circumstance to which the occasionally horny condition of the skin and the difficulty of perfectly disinfecting it may no doubt contribute.

In the palmar flap operation the incisions are carried comparatively high up upon the sides of the limb, and there is a little more disposition for the styloid processes to be exposed when the flap is adjusted.

The *circular operation* has the merit of being readily performed.   It affords, however, a somewhat scanty covering to the bones, and the cicatrix is placed at the extremity of the stump and over the prominences of bone.

If the tissues of the palm or of the dorsum have been thickened by inflammation, there may be some difficulty in dissecting up the covering of soft parts.

CHAPTER V.

AMPUTATION OF THE FOREARM.

Instruments.—An amputating-knife, with a blade four to five inches in length. A stout scalpel. An amputating-saw. Retractors (the linen retractor used to protect the soft parts during the sawing of the bones may have three "tails," the middle and narrowest slip being passed through the interosseous space). Pressure and dissecting forceps. Scissors, needles, etc.

Position.—The arm is abducted, and the surgeon stands to the right of the limb in all cases—*i.e.* to the outer side of the right forearm and the inner side of the left.

One assistant—to the operator's left—steadies the upper arm and retracts the flaps, etc. The other—to the operator's right—manipulates the forearm and hand, and attends to the sponging, etc.

The following *operations* are described :—

1. Circular method.
2. Anterior and posterior flaps.

1. The Circular Method (*through the lower third*). —The circular cut in the skin will be placed at a distance below the future saw-line equal to the antero-posterior diameter of the limb at that line.

The steps of the operation have been given on page 77.

2. By Antero-posterior Flaps (*through the upper two-thirds*).—The base of each flap should be equal to half the circumference of the limb at the level of the saw-line.

The length of each flap will depend upon the condition of the tissues. The arterial supply is the best on the anterior surface, and the saw should always be placed on the dorsum. Hence the anterior flap may well be made the length of

the antero-posterior diameter at the point of section, the posterior flap about one-half as long.

The flaps are ∪-shaped, and the lateral incisions correspond to the lateral margins of the limbs. The anterior flap will contain the supinator longus and the flexor muscles. The posterior flap will contain the extensors. In the radial incision the vertical cut will involve the two extensors of the radial side of the carpus. In the lateral ulnar wound the flexor profundus and the flexor carpi ulnaris are found to be marked by the vertical incision.

The hand having been supinated, the anterior flap is marked out by a skin-cut. In the case of the right limb, the knife is entered at the commencement of the ulnar incision, is carried down along the ulnar border, and is then made to sweep transversely across the flexor surface of the limb. The knife being withdrawn, its point is entered at the upper end of the radial incision, and is carried down along the radial border of the forearm to meet the first incision. The flap is marked out, therefore, by two cuts, and the incision is commenced on the side more remote from the surgeon. In the left limb the knife is first entered upon the radial border.

The elbow being now flexed so that the forearm is vertical (the hand being still supine), the posterior flap is marked out in the integuments only. The skin thus fashioned for the future flaps is allowed to retract. The forearm is now again held horizontally, with the elbow a little flexed and the hand still supine. The operator lifts up the tissues on the front of the limb with the fingers of the left hand, and proceeds to transfix. The knife is entered at the angle of the wound nearest to the surgeon, and is made to follow as accurately as possible the curves of the bones and the interosseous membrane. Its point should just graze the bones as it moves across the limb. While the assistant extends the hand, the surgeon cuts a muscular flap from within outwards, bringing the knife out sharply just at the level of the retracted skin.

The posterior flap is cut by transfixion in the same way, the limb being held in the same posture. It is difficult to

insinuate the knife behind the ulna, and its movements in that position must be assisted with the left fingers.

While the muscular tissue is being divided the assistant flexes the hand. The two flaps are now drawn up to the level of the saw-line, and the remaining soft parts are divided at that level to fully clear the bones.

This is effected by what the French surgeons call the *"incision en 8 de chiffre"* (Fig. 35). The knife is so made to pass across the front and back of the limb as to follow the outlines of the bones and to well sever the interosseous membrane. The hand is kept supine, and both the anterior and posterior incisions are made from left to right, and both are commenced by the heel of the knife and completed by its point.

The threefold retractor having been applied, the bones are sawn in the manner already described.

Some surgeons advise that the median, ulnar, and radial nerves should be resected from the anterior flap.
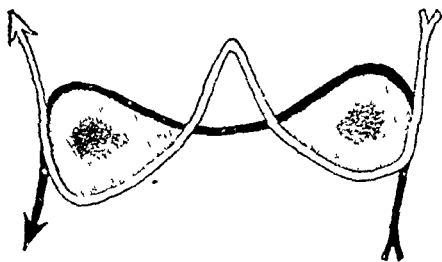
Fig. 35.—THE " INCISION EN 8 DE CHIFFRE."

The black and white arrows mark the course of the knife.

Hæmorrhage.—The radial artery will run the whole length of the anterior flap, and be cut near its outer border on the inner side of the supinator longus. The radial nerve accompanies it. The ulnar artery will be cut shorter, will be in front of the bone, and between the flexor sublimis and flexor profundus digitorum. The anterior interosseous vessels will be divided immediately in front of the interosseous membrane. The posterior interosseous artery will be cut long, and will be found between the superficial and deep muscles.

The more conspicuous nerves form good guides to the divided vessels.

CHAPTER VI.

Disarticulation at the Elbow-Joint.

Instruments.—An amputating-knife some six to seven inches in length for transfixion operation. A stout knife with a cutting edge of four to five inches, when flaps are cut from without inwards, and for disarticulating. A scalpel; retractors; pressure, artery, and dissecting forceps; scissors, needles, etc.

Position.—The arm is abducted to a right angle. The surgeon—except in an instance below specified—stands to the right of the limb in all cases—*i.e.* to the outer side of the right elbow and the inner side of the left.

One assistant, standing to the operator's left and near the patient's shoulder, steadies the arm, retracts and supports the flaps, etc. The other, to the surgeon's right, holds and manipulates the hand and forearm.

The following *methods* will be described :—

    1. The circular.
    2. The elliptical.
    3. The large anterior flap.

1. Circular Method.—In order to prepare for the unequal retraction of the skin, the incision must be a little oblique.

Over the supinator longus it should be about three inches below the joint-line, and over the posterior border of the ulna one inch and a half below that level.

Grasping the arm with his left hand, while an assistant holds the forearm, the surgeon makes the circular incision with one sweep. He begins with the heel of the knife and upon the side of the limb nearest to him, and in order to

reach that side he passes his own forearm beneath the patient's limb.

The incision involves the skin only, and the integuments are allowed to retract. When retraction has taken place, the skin ceases to appear to have been divided obliquely.

When the integuments have been retracted to a point about one inch below the line of the articulation, the superficial muscles are divided by a circular sweep at that level.

The skin is further retracted until the condyles are reached, and the deeply-placed muscular tissue which is still undivided is cut immediately over the joint. An assistant draws up the divided parts.

The surgeon now grasps the forearm with his left hand, and, keeping the elbow fully extended, cuts the anterior ligament and then the lateral ligaments; or he may directly enter the joint from the outer side by dividing the external ligament. Nothing now connects the limb with the trunk but the posterior ligament and the triceps.

The tendon of that muscle is the last structure severed.

The skin which formerly covered the olecranon now forms a pouch, and an opening for a drainage-tube should be made in the centre of this depression.

The wound is united so as to form a transverse cicatrix.

Hæmorrhage.—The radial and ulnar arteries will be divided just below their point of origin, or the brachial will be severed close to the bifurcation. In front of the outer condyle the superior profunda, lying by the musculo-spiral nerve, may require a ligature, and the same applies to the termination of the inferior profunda behind the internal condyle.

2. **Elliptical Methods.** — This operation may be illustrated by the

Anterior Ellipse.—The figure described by the incision is rather lozenge-shaped than elliptical.

The highest point of the ellipse is behind, over the prominence of the olecranon. The lowest point is on the anterior surface of the limb, over the eminence formed by

the supinator longus, and at a spot a little above the
middle of the forearm (Fig. 36).

In performing this operation the surgeon may con-
veniently stand to the left of the limb to be removed—*i.e.*
to the inner side of the right forearm and the outer side
of the left. The elbow will be on his
right hand, the hand on his left.

The elliptical incision may be made in
one sweep from olecranon to olecranon.

Holding the wrist in his left hand,
and flexing the elbow a little, the
surgeon so rotates the limb as to turn
the farther side of the forearm towards
him. (This will be the radial margin
on the right limb, and the ulnar
margin on the left.)

He carries the incision downwards
from the olecranon to the lower ex-
tremity of the ellipse.

As the knife crosses the anterior
aspect of the limb, the forearm is kept
extended, with the hand supine.

The elbow is once more flexed, and
the limb is now so held as to bring
uppermost the border of the forearm
nearest to the surgeon.

The knife is carried upwards across
the border to terminate at the point of
commencement over the olecranon
(Fig. 36).

Fig. 36.—DISARTICU-
LATION AT THE
ELBOW - JOINT BY
THE ANTERIOR
ELLIPSE METHOD.

The incision involves the skin only.

An assistant now takes the forearm, while the surgeon
separates and retracts the integuments a little all round.

This retraction will shorten the anterior flap about one
inch and a half.

The elbow being a little flexed, and the hand supine,
the operator pinches up the soft parts on the flexor aspect
of the bones with the left hand, and then transfixes the
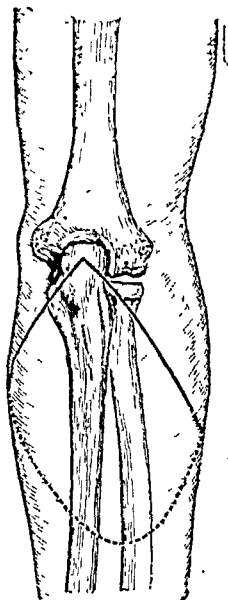limb transversely. The knife should be entered as near

the joint as possible, and should pass close to the anterior surfaces of the radius and ulna.

The muscles are cut obliquely, and an anterior flap is thus formed.

An assistant draws up this flap, and the surgeon, keeping his knife close to the bones and almost flat, cuts upwards until the anterior aspect of the joint is reached.

Fig. 37.—DISARTICU-LATION AT THE ELBOW - JOINT BY ANTERIOR FLAP.

Nothing now remains but to disarticulate in the manner already described, and to divide the triceps and any tissues which have escaped division along the lateral and posterior aspects of the limb.

A curved cicatrix on the posterior aspect of the limb results.

Hæmorrhage.—In addition to muscular branches, divided with the cut muscles, the radial and ulnar arteries will be found severed near the free end of the anterior flap; and on the deep surface of that flap the interosseous artery, and possibly the posterior ulnar recurrent, may require ligature. Bleeding may also occur from the terminations of the superior profunda in front of the external condyle, and of the inferior profunda behind the inner condyle.

3. **By Large Anterior Flap.**—The base of the flap should represent more than half the circumference of the limb, and should be U-shaped.

The anterior incision should commence three-quarters of an inch below the line of the joint on the inner side, and one inch and a half below that line on the outer side. The extremity of the flap (the curve of the U) should reach some three inches below the articulation.

The posterior incision is made to connect directly the extremities of the anterior incision (Fig. 37).

The position of the operator has been already indicated. The anterior flap should be marked out by a skin incision, the limb being at the time extended and the hand supine, and the knife should be entered upon the border of the forearm most remote from the surgeon.

The muscular part of the flap is cut by transfixion, precisely as in the anterior elliptical method.

The flap is drawn up, and the posterior incision made.

The operation is completed as in the disarticulation by the anterior ellipse, and the blood-vessels are divided in the same manner.

Many surgeons cut a short posterior flap about one-half or one-third the length of the anterior flap.

Comment.—Several methods of disarticulating at the elbow-joint have been advised or practised, in addition to those described. Among these may be mentioned the amputation by lateral flaps, the external being the larger; by antero-posterior flaps, the anterior predominating; and by a racket incision, the *queue* of which is over the olecranon; and by a single external flap.

The *elliptical method*—and notably the amputation by the anterior ellipse—is on the whole the best, provided, of course, that the tissues upon the flexor side of the limb are sound.

CHAPTER VII.

Amputation of the Arm.

Instruments.—An amputating-knife equal in length of blade to one and a half times the width of the limb for transfixion. A knife with a still longer blade for the circular method. A stout knife, some four inches in length, with which skin-flaps may be marked out and muscles separated from the bone. An amputating-saw. Some seven or eight pressure forceps. Artery and dissecting forceps. Scissors, retractors, etc.

Position.—The patient lies upon the back, and near to one or other edge of the table, according to the side of the amputation.

The limb is horizontal, and is abducted until it is at right angles to the body.

The surgeon stands to the outer side of the right arm and the inner side of the left.

One assistant holds the hand and forearm, and manipulates the limb. A second stands above the surgeon, and attends to the retraction of the divided parts. A third assistant commands the main artery.

The following two *methods* will be described. The first-named is considered to apply especially to the lower half of the arm, the second to the middle of the limb :—

      1. The circular method.
      2. By antero-posterior flaps.

   1. **The Circular Method** (*lower half of the limb*).— Fixing the arm with his left hand, the surgeon makes a circular sweep through the skin. To effect this he passes his hand beneath the limb, and bending his wrist over the patient's arm, he commences his incision with the heel of the knife, upon the surface of the limb nearest to himself

(*i.e.* upon the outer surface of the right arm and the inner surface of the left).

The assistant holding the forearm so rotates the limb as to make the tissues meet the knife.

The further steps of the operation have been indicated on page 78.

Hæmorrhage.—The vessels are divided upon the face of the stump—the brachial to the inner side with the median nerve; the superior profunda upon the postero-external aspect of the bone with the musculo-spiral nerve; the inferior profunda to the inner side of the brachial with the ulnar nerve. In addition to these three vessels, several muscular branches will need to be secured.

2. **By Antero-posterior Flaps** (*middle of the limb*). —The base of each flap should be equal to one-half the circumference of the limb.

The length of the anterior flap should equal that of the diameter of the limb. The posterior flap should be half the length of the anterior.

Both are U-shaped, and the incisions defining them are commenced just below the future saw-line (Fig. 38 B).

These incisions are so disposed that the brachial artery comes in the posterior flap, and great care must be taken that the division between the flaps is not just over the vessel, which would in such case probably be split in cutting the flaps by transfixion.

An assistant, grasping the limb by the elbow and wrist, flexes the forearm and rotates the extremity as required.

In marking out the anterior flap the arm is so rotated that the flexed forearm is carried towards the surgeon. The incision is commenced on the side of the arm farthest from the operator (*i.e.* on the ulnar side of the right arm and the radial side of the left).

The knife is carried from above downwards. As it sweeps across the front of the limb to form the tip or bend of the U, the arm is held straight, and as the blade is carried upwards to complete the other limb of the U, the arm is so rotated that the forearm is carried away from the surgeon.

The posterior flap is marked out with the knife in the same way, the arm being lifted up so that the surgeon can see the posterior surface.

These incisions concern the skin only.

The skin having been evenly freed all round, the anterior and posterior flaps are cut by transfixion, the edge of the knife being brought out at the level of the retracted skin.

As already said, care must be taken neither to transfix nor to slit the brachial artery.

The bone having been freed up to the saw-line, and the flaps well drawn up, the humerus is divided, care being taken of the musculo-spiral nerve.

The objections which have been urged against the cutting of the whole flap (muscles and skin) by transfixion apply with especial force to this part.

The flaps so cut are cut without precision, and the muscles and skin are divided at the same level.

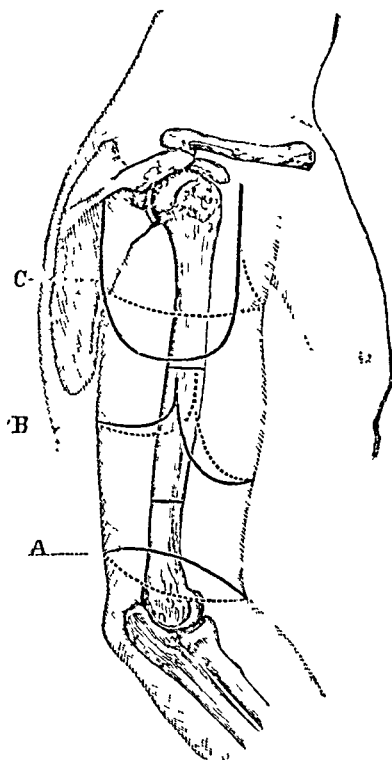Fig. 38.—A, Circular (inclined) amputation of the arm ; B, Amputation of the arm by antero-posterior flaps; C, Amputation at the shoulder-joint by deltoid flap.

The rapidity with which the operation may be performed is its sole recommendation.

Hæmorrhage.—Some muscular arteries are divided in the anterior flap. In the posterior flap the brachial, the superior profunda and the inferior profunda are found severed.

Comment.—The circular operation is peculiarly well adapted for the lower half of the arm, and is undoubtedly the best procedure for amputation in that situation. The method is not applicable to the upper half of the limb, owing to the freedom of the muscles, and their consequent ready retraction. It is here, therefore, that the flap operation proves so serviceable.

CHAPTER VIII.

DISARTICULATION AT THE SHOULDER-JOINT.

Methods of Controlling Hæmorrhage during the Operation.—1. The method of controlling bleeding by means of an elastic band, which is carried across the axilla and brought well up over the point of the shoulder, is strongly to be condemned as useless and dangerous. In such a method the axillary artery is compressed mainly against the humerus. At the moment of the disarticulation the band is apt to slip. It is in the way of the operator, and cannot with any ingenuity be made trustworthy.

2. The compression of the subclavian artery in the neck against the first rib is a more certain mode of controlling bleeding.

The vessel is compressed with the fingers or with an instrument shaped like the handle of a door-key.

Except under special circumstances, compression of the subclavian is not to be advised. Even with a skilled and careful assistant the method is not absolutely trustworthy. The fingers are apt to slip during the movements of the limb or of the patient, and the assistant who controls the artery is somewhat in the way.

The methods that are the most valuable are the two next described.

3. The main artery may be compressed in the flap by the fingers of an assistant, who takes hold of the part immediately before the vessel is divided.

This procedure is described in the account of Spence's operation.

4. The artery may be exposed and ligatured before it is divided, and early in the course of the operation. Although

not generally done, this preliminary ligature might form one step of Spence's operation.

Methods of Operating.—The following *modes of disarticulating at the shoulder* will be described :—

> 1. The racket method.   Spence's operation.
> 2. The external or deltoid flap.

Instruments.—A stout knife with a blade four to five inches in length. (If a transfixion operation be performed, an amputating knife with a blade equal in length to one diameter and a half of the limb will be required.)   A scalpel.   Ten pressure forceps.   Artery and dissecting forceps.   An aneurysm needle, metal retractors, scissors, etc.

Position.—The patient lies close to the edge of the table, with the shoulders raised and the head turned to the opposite side.   The upper limb is carried a little from the side.

The surgeon should stand to the outer side of the limb in the case of both the right and the left arm.   It is often, however, more convenient to stand to the inner side of the left extremity.

Three assistants are required.   One stands above the operator, by the patient's head, and, leaning over the shoulder, retracts the flaps and compresses the axillary vessels before they are divided.

A second assistant, standing below the surgeon, by the patient's hip, holds the limb, and manipulates it as required.

The third attends to the sponging.   He is placed either facing the surgeon and upon the other side of the table, or by the shoulder.

1. **The Racket Method.**—*Spence's Operation.*—The following is Prof. Spence's own account ("Lectures on Surgery," vol. ii., page 662) :—

"(1) Supposing the right arm to be the subject of amputation.   The arm being slightly abducted, and the head of the humerus rotated outwards if possible, with a broad, strong bistoury I begin by cutting down upon the head of the humerus, immediately external to the coracoid process, and

carry the incision down, through the clavicular fibres of the deltoid and pectoralis major, till I reach the humeral attachment of the latter muscle, which I divide.

"I then, with a gentle curve, carry the incision across and fairly through the lower fibres of the deltoid towards the posterior border of the axilla, unless the textures be much torn. (The incision so far is carried the whole length directly down to the bone.)

"I next mark out the line of the lower part of the inner section by carrying an incision through the skin and fat only, from the point where my straight incision terminated (*i.e.* at the lower end of the insertion of the pectoralis major), across the inside of the arm, to meet the incision at the outer part (Fig. 39). This ensures accuracy in the line of union, but is not essential.

Fig. 39. — DISARTICU-
LATION AT THE
SHOULDER BY
RACKET INCISION.
(*Spence's operation.*)

"(2) If the fibres of the deltoid have been thoroughly divided in the line of incision, the flap so marked out can be easily separated (by the point of a finger, without further use of the knife) from the bone and joint, together with the trunk of the posterior circumflex, which enters its deep surface, and be drawn upwards and backwards so as to expose the head and tuberosities.

"(3) The tendinous insertions of the capsular muscles, the long head of the biceps and the capsule, are next divided by cutting directly on the tuberosities and head of the bone (the humerus being rotated by the assistant as required). The broad subscapular tendon especially, being very fully exposed by the incision, can be much more easily and completely divided than in the double-flap method. By keeping the large outer flap out of the way by a broad copper spatula or the finger of an assistant, and taking care to keep the edge of the knife close to the bone, as in

excision, the trunk of the posterior circumflex is protected.*

"Disarticulation is then accomplished, and the limb removed by dividing the remaining soft parts on the axillary aspect."

(4) The final step of the operation is effected as follows :—
The arm, abducted and rotated out, is thrust upwards by an assistant until the head of the bone is projecting well above the glenoid cavity. The surgeon, taking hold of the head thus made prominent, draws it away from the trunk, while he passes his knife behind it so as to cut the posterior part of the capsule and the only remaining tissues—those of the axilla—which connect the arm to the trunk.

An assistant follows the knife with his two thumbs, while he keeps the fingers of both hands spread out over the axillary integument. Just before the main vessels are divided he firmly compresses them, and holds the flap until the several trunks are secured.

All the soft parts on the axillary aspect are divided with one sweep of the knife, which is made to emerge from the skin wound already marked out. The operation is completed by cutting the axillary nerves short, and by uniting the wound so as to form a vertical cicatrix.

Spence pointed out that the main vessel might be secured by ligature early in the operation, if thought well. "By a few touches of the bistoury," he writes, "the vessel can be exposed, and can then be tied and divided between *two ligatures, so as to allow it to retract before dividing the* other textures."

In disarticulating, the capsule should be divided transversely by a cut made upon the head of the bone. The three muscles attached to the greater tuberosity are cut while the humerus is being rotated in, the subscapularis while it is being rotated out:

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* This is a point of much importance, as, unless special care is taken, the posterior circumflex artery is apt to be divided or notched close to its origin. If this accident happens, not only is the nutrition of the deltoid and skin endangered, but considerable trouble may be found in tying the vessel.

Hæmorrhage.—The main artery is divided between the origins of the posterior circumflex artery and the superior profunda.

On the edges of the vertical incision there may be bleeding from the humeral branch of the acromio-thoracic artery, and in the depths of that incision the anterior circumflex artery will be divided.

There will be bleeding from muscular branches in the deltoid flap, and considerable hæmorrhage should the posterior circumflex artery be unintentionally cut.

2. **The External or Deltoid Flap Method.**—The base of the flap extends from the coracoid process in front to the spine of the scapula at the root of the acromion behind. It is U-shaped, and its extremity reaches nearly to the insertion of the muscle. If well shaped, the flap includes practically the whole of the deltoid. At its base it should be represented by the entire thickness of the muscle, while at its margins it should be comparatively thin.

The surgeon should always stand at the outer side of the limb, and almost facing the patient.

(1) The flap is marked out by a skin-incision. In dealing with the right shoulder, the arm should be carried well across the chest, and the knife be entered at the root of the acromion. It is then made to follow the outline of the deltoid, and to end at the coracoid process (Fig. 38, A).

As the knife is carried up towards the latter point the arm is withdrawn from the chest and a little abducted.

It is more convenient that the surgeon should manipulate the limb himself with his left hand.

On the left shoulder the process is reversed. The arm is drawn away from the side, and the incision commences at the coracoid. As it approaches the acromion the arm is brought across the chest.

(2) The knife is now carried deeply along the whole length of the incision, and the flap containing the substance of the deltoid muscle is raised. In cutting the flap the knife should be held a little obliquely, in order that the section of the muscle may be comparatively thin at the margins of the flap.

The flap is drawn well upwards by an assistant, and the outer surface of the shoulder joint is thereby exposed.

(3) A transverse incision, involving the skin only, is now made across the inner side of the arm, about two inches below the outlet of the axilla. It joins the great wound in front and behind.

(4) Disarticulation is finally effected in the manner already described, and the operation is completed precisely as in Spence's method. That is to say, after the disarticulation the head of the bone is thrust upwards and outwards, and is grasped by the surgeon, who passes his knife behind it so as to cut the very short internal flap. In effecting this the knife at first passes downward close to the bone, and divides the pectoralis major, latissimus dorsi, and teres major muscles. It is then made to cut its way sharply outwards through the incision already made in the skin.

In this, the last movement of the knife, are divided the coraco-brachialis, biceps, and triceps, with the axillary vessels and nerves.

An assistant follows the knife with his thumbs, and compresses the great vessels, before they are cut, in the manner already detailed.

Hæmorrhage.—In the deltoid flap there will be bleeding from the muscular branches only, notably from such as are furnished by the acromio-thoracic artery. The posterior circumflex artery will have been cut. The axillary vessels are divided at the free edge of the inner flap, the artery being cut below the origin of the two circumflex vessels. These arteries will be found severed in the margin of the inner flap, and the posterior of the two will certainly require a ligature.

This operation has little to recommend it except rapidity of execution. The flap is not so good as that formed out of the deltoid alone, a very wide section of muscles is made, and the procedure has no advantages which can counterbalance the difficulty attending its performance.

Comment.—Of the two operations described in this chapter, the best is undoubtedly the racket method performed on the general lines of Spence's description.

CHAPTER · IX.

Amputation of the Upper Limb together with the Scapula.

This amputation involves the removal of the upper limb, together with the scapula and the outer two-thirds of the clavicle. No disarticulation is attempted at the shoulder-joint.

The best method is that of Paul Berger, by two flaps—an antero-inferior or pectoro-axillary flap, and a posterior-superior or cervico-scapular flap.

Instruments.—A *strong, stout amputating-knife, with* a blade from five to six inches in length; a stout scalpel; a periosteal elevator or rugine, curved on the flat; metal retractors, spatulæ, and blunt hooks; a keyhole-saw or a fine chain-saw; bone forceps, lion forceps, aneurysm needle, pressure forceps, artery and dissecting forceps, scissors, etc.

Position.—The position of the surgeon varies with each step of the operation, and is described below. Three assistants should be at his service.

Steps of the Operation.—The amputation may be divided into four stages.

1st. The clavicle is exposed, and is divided at the junction of the middle with the inner third. The middle third of the bone is excised. The subclavian vessels are exposed, and are secured by double ligatures and divided.

2nd. The antero-inferior flap is fashioned and the brachial plexus severed.

3rd. The postero-superior flap is fashioned.

4th. The extremity is removed by dividing the tissues still connecting the scapula with the trunk.

The Operation.—1st Step.—The patient lies upon the back, close to the edge of the operating-table. The

shoulders are raised upon a hard cushion. The arm is by the side or a little separated from it. The surgeon stands to the outer side of the limb, facing the patient. Two assistants are placed, one on each side of the surgeon. A third assistant stands on the other side of the body and facing the operator.

The clavicular incision is now made with a stout scalpel. The incision is horizontal, is made along the surface of the bone, commences internally at the outer border of the sterno-mastoid muscle, and ends externally just beyond the acromio-clavicular articulation.

The knife divides everything down to the bone.

At this stage the sometimes large connecting vein which may pass between the external jugular and cephalic veins may be severed.

The periosteum of the clavicle is divided along the horizontal line corresponding to the original wound, and is also divided vertically or circularly at the inner extremity of the wound.

The inner third of the clavicle is not disturbed in any way.

By means of a small rugine or periosteal elevator curved on the flat, the periosteum is separated from the superficial part of the middle portion of the bone, which is now well exposed.

During the use of the elevator an assistant should steady the collar-bone, and render it as prominent as possible.

A large blunt hook may now be very carefully passed round the inner end of the exposed clavicle, and while an assistant draws the bone forward and steadies it by means of this hook, the surgeon saws it through at about the junction of the middle with the inner third. The section is accomplished by means of a keyhole-saw or by a fine chain-saw, the former being the more convenient.

The blunt hook serves to guide the saw and in some way to protect the deeper parts. During the sawing the middle of the clavicle should be grasped and further fixed by means of lion forceps. The bone is the more conveniently divided (with the hand-saw) if the blade be directed

downwards, outwards, and backwards. A perfectly straight
vertical section of the bone is difficult and unnecessary.

The outer fragment of the divided clavicle is now
drawn forwards by the lion forceps, the remaining peri-
osteum is separated from its posterior and deep surfaces,
and the bared bone is then again sawn through at the outer
end of the middle third.

The middle third of the clavicle is thus entirely re-

Fig. 40. —INTERSCAPULO-THORACIC AMPUTATION.

moved.   The exposed subclavius muscle is now isolated, is
divided close to the site of the inner section of the bone,
and is dissected up so as to expose the great vessels, and
turned outwards.

Fasciæ of varying thickness will have to be divided
before the vessels are reached.

A double ligature is passed round both the artery and
the vein, and between the ligatures each vessel is divided.

The ligature takes place at the lower border of the first
rib, and the artery should be exposed and secured before
the vein in order that as little blood as possible may be left

in the extremity.   In some cases ligature of the vein has been left to a later stage, when the anterior flap has been reflected.

2nd Step.—While the patient is still lying on the back, the body is brought as near to the couch as possible, and the shoulder is made to project beyond it.

An assistant draws the upper limb away from the body, and the surgeon stands to the inner side of the limb, *i.e.* between it and the trunk.   The whole of the scapular region should be free of the table, the back resting upon the hard cushion, which is at the very edge of the table, and the head being drawn to the opposite side.

The assistant moves the limb as required during the cutting of the pectoro-axillary flap.

The incision marking out this flap is commenced at the centre of the clavicular incision, is next curved downwards and outwards, passing just beyond (*i.e.* to the outside of) the coracoid process, and then runs along the deltoid muscle, parallel to, but to the outer side of, the groove between that muscle and the pectoralis major (Fig. 40). On reaching the point where the anterior wall of the axilla joins the arm, the incision crosses the lower margin of the pectoralis major, and passing transversely across the skin upon the inner or axillary surface of the arm, reaches the lower margin of the tendons of the latissimus dorsi and teres major.   At this point the limb is well raised by the assistant, and the wound is completed by carrying the knife downwards and inwards, to stop over the posterior surface of the inner angle of the scapula.   In the last part of the course the knife follows the groove between the vertebral border of the scapula and the muscular mass formed by the teres major and latissimus dorsi.

The incision involves at first only the skin and the subcutaneous tissues.

The surgeon now dissects up the structures of the flap which comprise the soft parts of the pectoral and axillary regions.

The pectoralis major is divided about where it is becoming tendinous, the pectoralis minor is severed close to

the coracoid process. An assistant holds back the tissues of the flap, while the surgeon exposes the cords of the brachial plexus, which are then divided at the same level as the main vessels, *i.e.* close to the first rib.

The shoulder now falls outwards away from the trunk, and the axilla is fully opened up. Any undivided connections of the limb in the axillary region are freed.

The latissimus dorsi is severed in the line of the incision, and serves to form part of the flap.

3rd Step.—The patient lies still in the same position at the extreme edge of the table, but the arm is now carried across the chest by an assistant so as to well expose the scapular region, and the surgeon·takes his place to the outer side of the extremity.

He proceeds to cut the postero-superior flap.

The incision starts at the outer termination of the first or clavicular incision (*i.e.* at a point just beyond the acromioclavicular joint), and is carried backwards by the shortest route over the scapular spine to meet the termination of the anterior flap incision, at the inferior angle of the scapula (Fig. 40). The wound concerns the integuments only. The skin is well reflected in the upper part of the incision, so as to lay bare the trapezius muscle. This muscle is divided close to its attachments to the clavicle and scapula, and is entirely severed from its connections with the limb.

4th Step.—Nothing now remains but to sever the connections of the scapula with the trunk.

One assistant holds back the anterior flap, another the posterior. The limb is allowed to hang away from the side, supported by a third assistant, and steadied and directed by the left hand of the operator.

The operator himself may conveniently stand to the inner side of the right arm and the outer side of the left. The superior and vertebral borders of the scapula being made prominent, the following muscles are rapidly divided from above downwards close to the bone : the omo-hyoid, levator anguli scapulæ, rhomboideus minor and major, and the serratus magnus.

The limb is now free. The two teres muscles, the sub-

scapularis, and the supraspinatus and infraspinatus muscles go untouched with the amputated extremity.

Hæmorrhage.—The early ligature of the main vessel renders the bleeding in this formidable operation comparatively slight. In resecting the clavicle and exposing the great vessels no noteworthy bleeding is encountered. In fashioning the anterior flap hæmorrhage may be expected from several muscular arteries and from branches of the acromio-thoracic and long thoracic. The subscapular artery should not be disturbed, although its thoracic branch will be divided.

In fashioning the posterior flap no vessels of any note will be encountered except muscular branches in the trapezius muscle, which are divided as the muscle is cut.

It is during the fourth step of the operation that most hæmorrhage is to be expected. It will come from the vessels descending from the neck or from the suprascapular and the posterior scapular.

CHAPTER X.

AMPUTATION OF THE TOES.

IN dealing with the anterior part of the foot it must be remembered that the foot rests upon the heel, the head of the metatarsal bones, and the inner margin of the soles. In amputation, therefore, every care should be taken to save as much as possible of the metatarsus, and especially of the first metatarsal bone and the phalanges of the great toe. The same care need not be taken to preserve every possible part of the four outer toes. A sloughing stump has often resulted from too great anxiety to preserve these almost useless digits.

Instruments.—Stout, narrow scalpels, with blades from one inch to two inches in length, and with well-rounded points. A fine keyhole-saw, or minute Butcher's saw. Bone forceps. Dissecting and artery forceps. Tapes, or strips of aseptic gauze, to retract the toes. Scissors, needles, etc.

Position.—In all these operations upon the toes the patient should lie on the back, and the foot be brought well beyond the end of the couch. The surgeon should sit at the end of the table facing the patient. The assistants stand—facing the surgeon—one on each side of the end of the table. One should fix the limb and hold the toe, while the other attends to the wound.

The operations included in this chapter will be dealt with in the following order :—

A. Amputation of the distal phalanges.
B. Disarticulation at the metatarso-phalangeal joints.
C. Amputation of the toes *en masse* through the meta-tarsus.

AMPUTATIONS.

A.—AMPUTATION OR DISARTICULATION OF THE DISTAL PHALANGES OF THE TOES.

1. Disarticulation of the Last Phalanx of the Great Toe.—*Large Plantar Flap.*—Hold the toe between the thumb and first two fingers of the left hand—the thumb on the pulp of the toe, the fingers on the nail. Cut the plantar flap as the toe is thus held. Enter the knife—at right angles to the surface—just over the head of the first phalanx. Cut along the side of the toe to the pulp. This incision should be parallel to the phalanx and nearer to the dorsal than the plantar aspect. Shape the flap as shown (Fig. 41) and return to the same point on the opposite side. The incision should extend down to the bone.
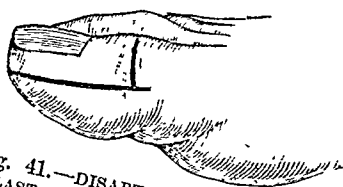
Let the assistant forcibly extend the last phalanx while the flap is dissected back, it being held by the left hand while so doing. In making this flap the surgeon must keep as close as possible to the bone. When the glenoid ligament is reached, cut it transversely against the base of the last phalanx. The joint is thus opened.

Fig. 41.—DISARTICULATION OF THE LAST PHALANX OF THE GREAT TOE BY A LARGE PLANTAR FLAP.

Now let the surgeon forcibly flex the toe and make across the dorsum a transverse cut that at once divides the extensor tendon and opens the joint. Rotate the toe out, and carefully divide the internal lateral ligament Rotate it in and divide the external band, and the disarticulation is complete. In disarticulating, keep the knife very close to the bone, so as to avoid wounding the plantar digital arteries. Cut the lateral ligaments from without inwards. The cicatrix of the stump will come well on the dorsum. The long plantar flap should not be cut by transfixion. By so doing the vessels are needlessly damaged and the flap is apt to be scanty. If, on the other hand, too large

a flap be cut, a pocket is made in which effusions may collect.

Hæmorrhage.—The two dorsal digital arteries will be cut at the corners of the dorsal incision. They are small, and usually do not need to be secured. If the flap has been well cut, the two plantar digital arteries will not be wounded, but will lie buried in the flap until they anastomose at its free end. They may readily be cut if in dissecting the flap back the knife is not kept close to the bone. They also lie near to the sides of the joint (plantar aspect), and may be easily wounded in careless disarticulation.
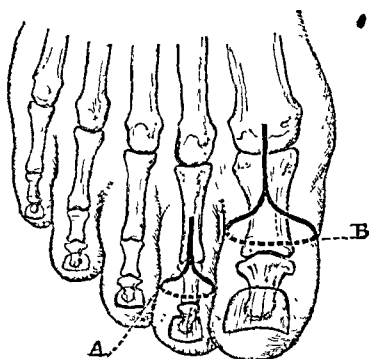

Fig. 42.—A, Disarticulation of the second phalanx of a toe by the racket or oval incision; B, Disarticulation of the great toe by the racket or oval incision.

2. **Amputation** or **Disarticulation of the Phalanges of the Four Outer Toes.**—In operating upon the smaller toes the neighbouring digits should be held aside by the assistant by means of sterilised tapes. It is well not to use too long a scalpel.

The terminal phalanges may be removed by the operation just described.

In *disarticulation of the second phalanx* use the oval or racket incision (Fig. 42, A), and proceed precisely as in the corresponding operation in the hand (see page 87).

Hæmorrhage.—Two dorsal and two plantar digital arteries are found cut in the lateral edges of the wound. The dorsal will require no attention; the latter may be twisted.

In *amputation through the first phalanx* employ the circular method. Make a circular cut round the phalanx at the level of the web; cut to the bone. As the knife crosses the dorsum flex the toe so as to cut the extensor

tendon short. As the scalpel crosses the plantar aspect, extend the digit to its utmost. Separate the soft parts from the phalanx as high up as possible, and divide the bone. Close the sheath of the flexor tendon (page 84). The vessels are cut as in the last instance. The cicatrix should be vertical, *i.e.* dorso-plantar. Amputation through the first phalanx may also be effected by two lateral flaps of equal size cut by transfixion with a narrow bistoury.

Comment.—In disarticulating the second phalanx, remove the head of the first phalanx, or replace the operation by an amputation through the latter bone at the level of the web. The head of the first phalanx is large, and is apt to play the part of a foreign body between the other toes when it is left. Its removal is no detriment to the use of the foot.

As has been observed elsewhere (page 95), the bone should be divided by a very fine saw rather than crushed by forceps.

B.—DISARTICULATION AT THE METATARSO-PHALANGEAL JOINTS.

1.—Disarticulation of the Great Toe at the Metatarso-Phalangeal Joint.—In this operation notice must be taken of the very large size of the head of the metatarsal bone. Its dimensions are increased by the presence of the sesamoid bones, which should never be removed with the phalanx. It is of considerable importance to the future use of the foot that the head of the metatarsal bone should be preserved, and it will be seen that the chief difficulty of the operation is to provide flap enough to cover the projection. It is important also that the scar should be away from the plantar surface and the line of the sesamoid bones.

The joint can be readily made out by manipulation, especially on the inner aspect of the foot. It is placed about an inch behind the web. The projection of the sesamoids can also very easily be defined.

(1) *By Internal Plantar Flap (Farabeuf).*—The

surgeon sits to the front and the inner side of the foot. The four surfaces of the digit—dorsal, plantar, internal, and external—should be noted and conceived to be each of equal extent. The joint-line is made out, and the toe being grasped with the left hand, the knife is entered over that line and at a point where the dorsal and internal surfaces meet. An incision, 2 cm. in length, is made along the toe, parallel to the extensor tendon and on the line between the two surfaces named. It is then curved downwards over the inner surface to the plantar margin (Fig. 43). The toe is now turned in, and the knife, placed beneath the member, is drawn across the plantar surface to the edge of the web between the toes. The knife is next held above the toe, and the incision completed by a cut to the point of starting, made by the shortest route. The whole of this incision should involve the skin only.

Fig. 43.—DISARTICU-LATION OF THE GREAT TOE BY INTERNAL PLANTAR FLAP.

It should now be deepened down to the bone in the same order. In drawing the knife across the plantar surface, extend the toe, so as to cut the flexor tendon high up. Dissect back the flap, keeping close to the bone. In so doing, the assistant should hold the toe and turn it to one or other side as required, while the surgeon uses his left fingers to turn back the soft parts. Separate the tissues about the point of starting; clear the soft parts from the surface of the joint. Forcibly extend the toe, and cut the glenoid ligament transversely close to the base of the phalanx. The joint is thus opened; the ligament, with the sesamoid bones, remains behind. Divide the lateral ligaments, and finally cut the extensor tendon. Close the fibrous sheath of the flexor tendon by two fine catgut sutures.

Hæmorrhage.—The outer plantar digital artery will be found cut close to the web, the inner vessel at the free end
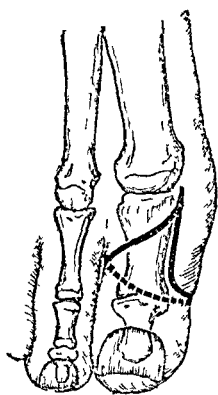
of the inner flap. The dorsal digital vessels will probably not need to be secured.

(2) *By Racket* or *Oval Incision.* — The toe is grasped by the left hand. The knife is entered about 1 cm. above the metatarso-phalangeal joint in the dorsal median line. It is continued down to the centre of the first phalanx, and when carried round the toe to form the racket should just avoid the web (Fig. 42, B). The proceeding is identical with that described in disarticulation of the second phalanx (page 132). The joint should be opened from below, through the glenoid ligament.

The fibrous sheath of the flexor tendon may be closed in the manner just described.

Comment.—In disarticulating, the toe should be manipulated by the assistant, while the surgeon holds back the soft parts with his left fingers. The toe should be turned and twisted to the inner side when dividing the outer lateral ligament, and to the outer side when dividing the inner one. In dissecting back the flap, it is well to keep close to the bone, so as to avoid injury to the digital vessels.

In disarticulating, also, care must be taken to keep close to the phalanx and to cut towards the bone; the soft parts must be well dissected back and the ligaments exposed. If such care be not taken, the plantar digital arteries — which lie close to the joint — will be divided. The cicatrix comes over the head of the bone and is vertical to the sole.

The digital arteries will be found divided at the free margin of the flap on either side.

When possible, the base of the first phalanx of the toe should be saved, on account of the important series of muscles to which it gives attachment (abductor and adductor pollicis, flexor brevis pollicis, and transversus pedis). Although these muscles can no longer act upon the toe, they are of value in maintaining the strength of the sole.

The skin in this region is often much thickened, and is consequently unyielding, and in adjusting flaps it is important to take care that too much strain does not come upon the sutures.

2. **Disarticulation of the Outer Toes at the Metatarso-Phalangeal Joints.**—The best operation is that by the *oval* or *racket incision*, described on page 135.

C.—AMPUTATION OF THE TOES EN MASSE THROUGH THE
METATARSUS.

This operation is carried out upon the same principles as that just described.

The best procedure is that of a **long plantar flap.** The foot should project beyond the end of the table, and the surgeon should sit facing it. The points at which the bones are to be sawn must first be determined. The saw-line must be oblique, so as to follow the natural line of the metatarsal bones—*i.e.* the section of the fifth metatarsal must be posterior to the section of the first metatarsal. The saw-cut, in fact, should be about parallel with the line of the web. The plantar flap may be cut first. This is done with the foot well flexed.

Assuming the left foot to be the one operated on, the knife is entered at the inner margin of the foot, midway between the dorsal and plantar surfaces. The point of entrance is over the first metatarsal, and is just behind the point at which that bone is to be divided. The incision is carried along the side of the foot until the level of the crease that separates the great toe from the sole is reached. It is now made to sweep across the plantar surface just behind the web. On reaching the outer surface of the little toe, the incision is carried back along the margin of the foot until a point is reached just posterior to the spot selected for the section of the fifth metatarsal bone. In making this plantar incision the surgeon should keep the foot rigid with his left hand, and at first the cut should be through the skin only. An assistant now takes the foot and keeps it well flexed at the ankle, while the surgeon uses his left fingers to aid in dissecting back the flap. The flexor tendons should be divided as soon as the separation of the flap has been well commenced. While they are being cut the individual toes must be fully extended.

The plantar flap should contain all the soft parts down to the bone.

The foot having been extended, the dorsal incision is made. It should be parallel with the plantar cut, and should join the lateral parts of the plantar flap about one inch from their points of commencement. In other words, this little flap is about one inch in length. The flap must include all the soft parts down to the bone. The extensor tendons should be divided when the flap is about half separated.

In dividing the bones, the plantar flap should be carefully protected by an ivory spatula. Each bone should be sawn separately from the dorsal aspect with a fine narrow saw. The rude crushing of the bones with cutting forceps is not to be advised.

It is to be remembered that the shafts of the metatarsal bones are embraced by the interossei muscles. These must be cleanly divided before the saw is applied.

The cicatrix comes upon the dorsum of the foot.

Hæmorrhage.—In the plantar flap six arteries (the digital) may possibly require to be secured. One will be found opposite to each of the four interosseous spaces, a fifth opposite the outer side of the fifth metatarsal, and a sixth opposite the inner side of the first metatarsal. The two latter vessels may not require to be secured. The largest vessel is that opposite the first interosseous space.

Vessels similarly placed will be divided in the dorsal flap. Probably none will require attention except the artery (the first dorsal interosseous) that is cut opposite the gap between the first and second metatarsal bones.

CHAPTER XI.

Partial Amputation of the Foot.

AMPUTATIONS THROUGH THE TARSO-METATARSAL JOINTS.

These operations consist in the removal of single toes, with their respective metatarsal bones, and in the removal of the whole of the metatarsus by Lisfranc's and Hey's operations.

Instruments.—A stout knife with a blade three inches long. (For the flap operation upon the great toe a more slender knife, with a blade of about three and a half inches in length). Narrow metal retractors. Lion forceps (in the event of the part being crushed). Dissecting, pressure, and artery forceps.

Position.—The same as for previous amputations. (*See* page 130.)

DISARTICULATION OF A TOE, TOGETHER WITH ITS METATARSAL BONE.

1. Disarticulation of the Great Toe, with its Metatarsal Bone, by Oval or Racket Incision.— Having defined the metatarso-tarsal joint, grasp the toe with the left hand, and enter the knife at the inner border of the foot, just below the line of the joint. Carry the incision outwards, parallel to the articulation line, until the centre of the dorsal aspect of the metatarsal bone is reached. Now continue the cut straight down towards the nail, along the median line of the dorsum of the bone. This incision will lie to the inner side of the extensor proprius pollicis tendon. On reaching the centre of the metatarsal bone, incline the incision to the web, then round the outer side of the root of the toe (the phalanx being turned out), and so on to the plantar aspect. Let

the knife cross the plantar surface transversely in the groove that separates the toe from the sole. Finally, curve the incision round the outer aspect of the toe to reach the dorsal wound at the centre of the metatarsal bone. The incision involves the skin only.

Now deepen the dorsal cut. Divide the tendons of the extensor proprius and extensor brevis close to the metatarso-tarsal joint. Separate the soft parts from the inner and outer sides of the bone, keeping close to it, and cutting from the tarsus towards the toe. While effecting this separation the assistant turns the toe to one or other side, and the surgeon uses his left fingers to draw away the soft parts. The assistant now partly extends the toe, and, the flexor tendon having been cut, the soft parts are dissected off from the plantar aspect of the bone. The bone should be bared back to the joint. The sesamoid bones are left behind.

Care must be taken not to wound the communicating branch of the dorsalis pedis artery which runs between the two toes.

The next step is to open the joint on the dorsal aspect, and so far as possible on the outer and inner sides. The surgeon now once more grasps the toe and divides the plantar and remaining ligaments. Last of all, the tendons of the peroneus longus and tibialis anticus are cut, and the toe with its metatarsal bone is free.

Cut the flexor tendon short, and close its sheath with fine catgut sutures. If the transverse cut at the commencement of the incision be not employed, the wound must start over the cuneiform bone.

Hæmorrhage.—The dorsal digital branches (of the first interosseous artery) to the sides of the toe are divided in the dorsal incision. The inner one will probably need no attention. In the plantar aspect of the wound are divided the termination of the internal plantar artery, the first plantar digital artery, and the internal digital branch to the great toe. There is great risk of wounding the communicating branch of the dorsalis pedis in the gap between the first and second toes.

2. **Disarticulation of the Little Toe, with its
Metatarsal Bone, by the Oval or Racket Incision.**
—The toe being grasped by the left hand, the knife is
entered at the outer margin of the foot about 1 cm.
behind the tuberosity or the fifth metatarsal bone.
An oblique cut—parallel with the cubo-metatarsal joint
—is made, and a median dorsal incision is carried thence
to the neck of the metatarsal bone. Here the oval is
made just as in the disarticulation of the great toe (page
138). The subsequent steps of the operation are practi-
cally identical with those already described.

Hæmorrhage.—In the dorsal incision the dorsal digital
arteries of the toe are divided, while the plantar digital
vessels are found cut on the plantar aspect of the wound.
Special care should be taken not to wound the plantar arch
in disarticulating the base of the metatarsal. In a case in
which this accident happened, not only was the bleeding
very difficult to check, but secondary hæmorrhage occurred
a few days later.

Any one of *the other metatarsal bones* may be removed,
with its corresponding toe, by the oval incision. The
outer two bones may in like manner be removed *together*
by the oval operation, the *queue* of the oval running along
the interosseous space between the two bones.

These operations are of little practical value.

LISFRANC'S OPERATION.

A disarticulation of the anterior part of the foot at the
tarso-metatarsal line.

Instruments.—A strong, stout, narrow knife, about
four or five inches long in the blade; a scalpel; a saw, which
will be required for Hey's or other modification; a narrow
metal spatula; pressure forceps, artery and dissecting
forceps; lion forceps if the toes be crushed.

Position.—The patient lies on the back. The foot
is drawn well beyond the end of the table, and is raised
upon a support until on a level with the surgeon's neck.
The operator may stand to cut the dorsal flap, but should

sit at the end of the table facing the patient to cut the sole
flap and complete the disarticulation.   The assistants stand
one on each side of the end of the table.

Operation. (*Right Foot.*)—1. *The Dorsal Flap.*—Grasp
the extended foot with the left hand, so that the thumb is
on the base of the fifth metatarsal
bone and the forefinger on that of
the first, while the palm of the
hand faces the sole.   The skin on
the dorsum is stretched, and the
knife is held in the free hand, with
the forefinger on the back of the
blade.   In this position the dorsal
flap is cut.   The incision com-
mences at the outer margin of the
foot, just behind the tubercle of
the fifth metatarsal bone (Fig. 44).
For about an inch it follows the
outer border of the bone.   It then
sweeps across the dorsum parallel
to the line of the tarso-metatarsal
joints and about half an inch in
front of it.   The cut is curved
towards the toes, and reaches the
plantar aspect of the inner border
of the foot about half an inch in
front of the tarsal joint of the
great toe.   It finally follows the
inner margin of the foot, and ends   Fig. 44.—LISFRANC'S AMPU-
three-fourths of an inch behind   TATION.
the said joint.

The assistant now holds the foot fixed in the extended
position while the surgeon uses his left fingers to dissect
back the dorsal flap.   The dissection at first includes the
skin only; but when the integument has been retracted
about one-fourth of an inch, the extensor tendons are
divided.   The flap contains therefore all the soft parts down
to the bones.   It is important to well expose the meta-
tarsus and to carry the flap back far enough to expose the

tarso-metatarsal joint-line.   (*See* the Comment upon the operation, page 144.)

2. *The Plantar Flap.*—The plantar flap is now cut. The surgeon flexes the foot with the left hand, his thumb being along the line of the toes and his fingers on the dorsum.   The knife is introduced at right angles to the surface of the now well-exposed sole.   The incision, commencing on the outer side, follows the plantar edge of the fifth metatarsal for a short distance, and then sweeps obliquely across the sole to the neck of the fourth metatarsal.   It now traverses the sole just behind the line of the
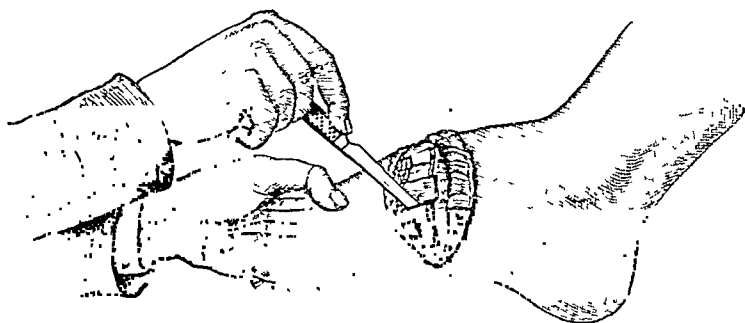

Fig. 45.—THE COUP DE MAÎTRE IN LISFRANC'S AMPUTATION · FIRST STEP.
(*After Guérin.*)

heads of the metatarsus, and finally follows the plantar edge of the metatarsal bone of the great toe to join the extremity of the dorsal incision.   The plantar flap is thus convex forwards, and the inner segment is longer than the outer (Figs. 44 and 49, A).

The incision at first involves the skin and the subcutaneous tissues only.   The assistant now grasps the toes and keeps them fully extended while the surgeon dissects back the flap.   This should include the subcutaneous structures only until the hollow behind the heads of the metatarsal bones is reached.   When this hollow is exposed, the tightly-stretched flexor tendons are divided by a vigorous transverse cut.   The rest of the flap includes

all the soft parts down to the bones. These are dissected up by short transverse cuts with the knife while the operator pulls back the flap. The separation is carried back as far as the line of the tarso-metatarsal articulations. The exposure of the peroneus longus will indicate when this line is reached. The tendon should for the present be left uncut.

3. *The Disarticulation.*—Return to the dorsum. Grasp the foot with the left hand and extend it fully. Let an assistant hold back the dorsal flap with one hand while by means of a metal spatula he retracts and protects the plantar flap with the other. Enter the knife just behind the tubercle of the fifth metatarsal bone, and, cutting obliquely forwards and inwards, open the tarsal joints of the three outer metatarsal bones. In this manœuvre the tendons of the peronei brevis and tertius are divided. Now turn to the inner side of the foot, and open the joint between the first metatarsal and the inner cuneiform, cutting at the same time the tibialis anticus expansion. In the next place, open the joint between the second metatarsal and the middle cuneiform on its dorsal aspect. The complete separation of the metatarsal bone is difficult, and is thus effected : Hold the knife like a trocar and— keeping it nearly parallel with the dorsum of the foot— thrust the point in deeply between the bases of the first and second metatarsal bones (Fig. 45) until it is arrested by bone. The edge is turned towards the ankle. Now grasp the knife in the hand like a dagger, and elevate the handle until it is perpendicular to the dorsum of the foot, at the same time cutting in the direction of the external malleolus (Fig. 46). By this manœuvre (the *coup de maître*) the strong ligament of Lisfranc is severed.

Divide any remaining ligaments, especially those on the plantar aspect of the joints, and finally the metatarsus is left attached only by means of the peroneus longus tendon. Draw this tendon out, and cut it at the outer angle of the incision, and the parts to be removed are free.

Left Foot.—Commence the dorsal and plantar incisions on the inner side of the foot. In disarticulating, open first

the joint between the metatarsal bone of the great toe and the inner cuneiform, then open the tarsal joints of the three outer metatarsals, and finally disarticulate the second metatarsal.

Hæmorrhage.—In the dorsal flap are divided the dorsal interosseous arteries (four), opposite to the interosseous spaces, and the plantar branch of the dorsalis pedis as it dips down between the bases of the first two metatarsal bones. In the plantar flap are divided the plantar digital branches of the external plantar, and probably that vessel itself, near
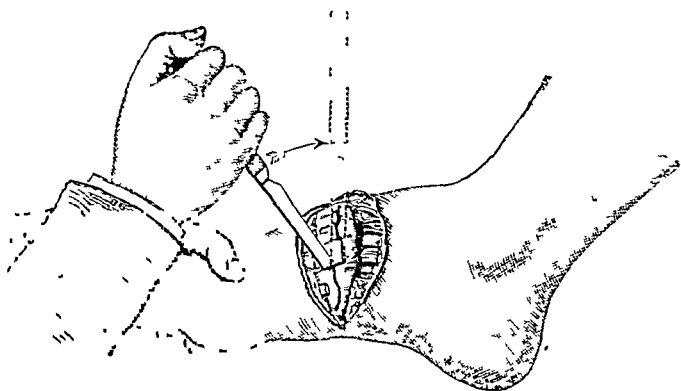

Fig. 46.—THE COUP DE MAÎTRE IN LISFRANC'S AMPUTATION : SECOND STEP.
(After Guérin.)

the base of the second metatarsal. The terminal part of the internal plantar artery is also divided.

Comment.—The dorsal flap having been made, the disarticulation may be at once proceeded with, and the operation completed by cutting the plantar flap from within outwards—*i.e.* practically by transfixion. Or, the disarticulation having been effected from the dorsum, the plantar flap may be subsequently cut in the manner already described. On the other hand, the operation may be commenced by cutting the plantar flap, and then be completed by the making of the dorsal flap and by disarticulation.

It is a common fault to make the dorsal flap too small,

and to limit it strictly to the dorsum. This flap should include not only the dorsal structures, but also the greater part of those of the outer and inner margins of the foot. The relative sizes of the two flaps may be estimated by noting the measurements of half the circumference of the foot at the amputation-line. An unduly large plantar flap forms an unwieldy pocket. If the dorsal incision be carried too far back, the joint between the scaphoid and cuneiform bones may be opened by mistake on the inner margin of the foot.

HEY'S OPERATION.

This operation resembles Lisfranc's procedure in all essential points, and differs only in this: the four outer metatarsal bones are disarticulated from the tarsus, and the projecting end of the internal cuneiform bone is sawn through, carrying the first metatarsal bone with it.

CHAPTER XII.

PARTIAL AMPUTATION OF THE FOOT (*concluded*).

AMPUTATION THROUGH THE MEDIO-TARSAL JOINT (CHOPART'S OPERATION).

THIS consists of a disarticulation of the foot at the medio-tarsal joint.

Instruments and **Position.** — The same as for Lisfranc's operation.

Operation.—In its main points the procedure is identical with Lisfranc's amputation.

1. *The dorsal flap.*—The incision commences at a point midway between the tip of the outer malleolus and the tuberosity of the fifth metatarsal on the outer side, and at a point just behind the tuberosity of the scaphoid on the inner side. The cut follows on either side the margin of the foot for a little distance, and is then so curved over the dorsum as to cross the bases of the metatarsal bones (Fig. 47).

2. *The plantar flap* extends between the two points first named. It follows in the main the lines of Lisfranc's flap, and has the same shape. It is so carried over the sole as to cross the middle of the metatarsus (Figs. 47 and 49, B). The flexor tendons are divided as soon as a little skin has been retracted. Both flaps contain all the soft parts down to the bones. The medio-tarsal joint-line should be well exposed.

3. *The Disarticulation.*—In disarticulating, the foot may be conveniently held in the position of talipes varus, and be well extended. Care must be taken to open the right joints. It is easy to open the scapho-cuneiform

joints in the place of the astragalo-scaphoid, and to actually leave the scaphoid behind.

The tendons that are especially to be noted in cutting the deeper parts are the three perenei and the two tibials.

Hæmorrhage.—In the dorsal flap, the dorsalis pedis artery is cut as it dips down between the first and second metatarsal bones.   The metatarsal and tarsal branches of that vessel are also divided.   The two saphenous veins come in this flap.

At the anterior part of the inner segment of the plantar flap the internal plantar artery is divided, and near the base of the second metatarsal bone the end of the external plantar.   In the outer part of the flap are the digital branches of the latter vessel.

SUBASTRAGALOID DISARTICULATION.

This operation consists of a disarticulation at the astragalo-scaphoid and astragalo-calcaneal joints.   The astragalus is the only bone of the foot that is left behind, and forms the summit of the stump.

Position and Instruments. —The same as in the preceding operation.

Fig. 47.—CHOPART'S AMPUTATION.

Farabeuf's Operation by a Large Internal and Plantar Flap.—In this procedure a large flap is cut from the sole and the inner aspect of the foot.

1. *The Line of Incision.*—The incision is commenced at the outer margin of the tendo Achillis at its insertion (Fig. 48, A), and is then curved up a little to reach the level of a point one inch below the outer malleolus.   It is now carried forwards horizontally, parallel to the outer border of the foot, and one inch below the malleolus (A to

B), and reaches a point (B) which is on a line connecting the base of the fifth metatarsal bone with the joints between the scaphoid and cuneiform bones. It then curves sharply inwards across the dorsum of the foot (B to X),
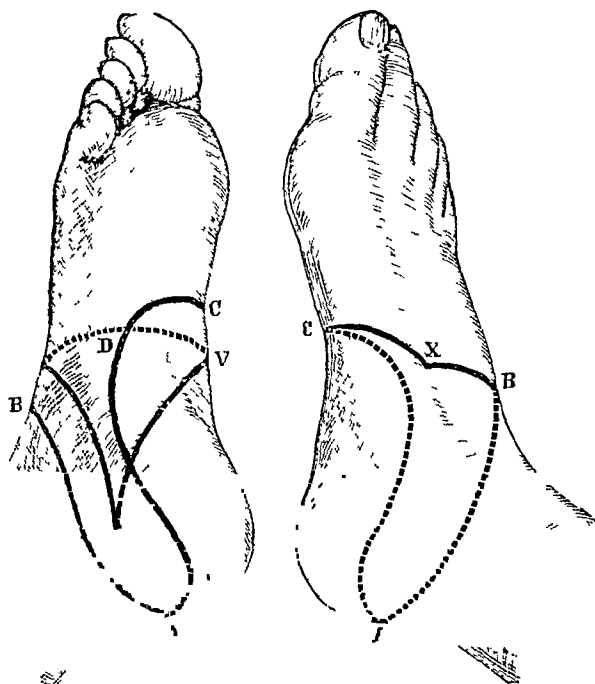

Fig. 48.—INNER AND OUTER SIDES OF THE RIGHT FOOT, TO SHOW THE INCISIONS IN FARABEUF'S SUBASTRAGALOID AMPUTATION.

V, The lines of Verneuil's subastragaloid amputation. (For other references, *see* text.)

a little in front of the joints named, and reaches the extensor proprius pollicis tendon at x. The incision next crosses the inner border of the foot so as to follow the line of the cuneo-metatarsal joint of the great toe (X to C).

It now sweeps across the centre of the sole of the foot (C to D), and is next rounded off and curved back so as

to follow exactly the outer border of the foot as far as the external tuberosity of the os calcis (E).   It is then curved up a little to end at the insertion of the tendo Achillis at A.   (*See* also Fig. 49, E, and Fig. 50, A). :

The foot must be turned from side to side by the surgeon's left hand as the devious line of this incision is followed.   The knife at first divides only the skin and the subcutaneous tissue.   It is then made to follow the incision a second time—when the skin has retracted a little—and is carried to the bone.   Care must be taken that the knife goes well down to the bone, and that all the soft parts are divided.   To effect this the blade must be used with considerable vigour.   The border or surface of the foot that is attached.must be put upon the stretch, so that the tendons are cleanly divided.   The peronei tendons are especially difficult to cut.   In making these deep sweeps with the knife the surgeon must take great care to avoid opening any joints, notably those between the scaphoid and the cuneiform bones.

2. *The Disarticulation.*—The leg having been flexed upon the thigh, the assistant turns the knee in with one hand and presses the lower part of the leg against the edge of the couch with the other.

The foot projects beyond the edge of the table, with its outer surface well exposed and lying horizontally.

Let the dorsal part of the flap (Fig. 48, x to A) be now dissected up sufficiently to well expose the head of the astragalus ; divide the tendo Achillis ; open the astragalo-scaphoid joint on its dorsal aspect.   Keep the knife between the bones, and, cutting backwards, pass it between the os calcis and the astragalus, and so sever the interosseous ligament.   This entails no difficulty if the outer surface of the foot be well exposed, and kept upon the stretch with the left hand.   As the ligament is divided, turn the os calcis more and more out.   See that all the tendons, etc., are divided on the outer side of the foot, and that the outer aspect of the os calcis is bared to the periosteum.

Now with the left hand twist the foot round until it is in the position of the extremest varus.   In this position

dissect—by cuts made from left to right in the left foot, and from right to left in the right foot—all the soft parts from the inner and under surfaces of the òs calcis. Special care must be taken of the vessels which lie in the hollow on the inner side of that bone.

Clear the under surface of the bone, still turning the foot out. When this process of enucleation is complete, the foot will have been so turned round that the dorsum will face downwards. Now separate the foot, and cut any neglected tendons short.

The suture line on the stump is horizontal, and is on the outer side of the extremity.

The operation is much easier on the left than on the right foot. In the latter case it may be more convenient to dissect up the great flap and bare the os calcis before the disarticulation is effected.

No drainage-tube is required as a rule.

Hæmorrhage.—In the part of the flap A to B (Fig. 48) are cut the posterior peroneal, the anterior peroneal, and branches of the tarsal and metatarsal arteries. The largest of these is the first named, which runs just behind the malleolus.

In the part B to X the tarsal artery and the dorsalis pedis—the latter a large vessel—are divided opposite the centre of the head of the astragalus. In the part X to D the internal and external plantar are cut. In the margin of the flap D to E branches of the latter vessel are found.

CHAPTER XIII.

AMPUTATION OF THE FOOT.

Two procedures will be described :—

    A. Disarticulation at the ankle-joint.

    B. Intracalcaneal amputation of the foot.

A.—DISARTICULATION AT THE ANKLE-JOINT (SYME'S AMPUTATION).

This is the principal operation for removing the entire foot. The flap is made from the heel, the soft parts having been peeled off the os calcis. The two malleoli, together with the articular surface of the tibia, are sawn off.

The *blood supply* of the heel-flap is a matter of great importance ; the two chief vessels of supply are the external calcaneal of the posterior peroneal on the outer side, and the internal calcaneal of the external plantar on the inner side. The first-named vessel is a continuation of the posterior peroneal. It runs just behind the inferior tibio-fibular joint, and then behind the outer malleolus to the heel. With regard to the internal calcaneal artery, the posterior tibial divides " on a level with a line drawn from the point of the internal malleolus to the centre of the convexity of the heel." This line is dangerously close to the line of the incision. The internal calcaneal artery arises from the external plantar, close to the bifurcation and under the fibres of origin of the abductor pollicis. Inasmuch as this is the chief vessel of the flap, the greatest care must be taken of it. (*See* page 155.)

Minute branches may reach the flap from the internal malleolar of the posterior tibial and from the outer and inner malleolar of the anterior tibial.

In removing the lower ends of the tibia and fibula the greater part of the anterior and posterior tibio-fibular ligaments, together with the interosseous ligament, are saved, while the transverse or inferior ligament is cut away with the bones.

Instruments.—A stout narrow knife, with a blade three inches long, a narrow but rounded point, and a large strong handle; a scalpel; a saw; two metal retractors to hold back the flaps when sawing the leg bones; lion forceps; pressure forceps; artery and dissecting forceps, scissors, etc.

Position.—The patient lies on the back, with the foot projecting beyond the end of the table and the toes pointing upwards. The surgeon sits facing the end of the table. The lower end of the leg is raised on a Volkmann's pelvic support to the level of the surgeon's face. The surgeon sits to cut the heel flap, and stands to cut the dorsal flap and to disarticulate. Two assistants stand facing the surgeon, one on each side of the end of the table. One steadies the foot, the other attends to the wound.

The Operation.—An assistant steadies the leg with one hand, and holds the foot—by the toes—rigidly at a right angle to the leg with the other hand.

1. *The Heel Flap.*—The incision starts from the tip of the outer malleolus, and in a line nearer to its posterior than its anterior border.

It is carried vertically down the heel, exactly at right angles to the long axis of the foot, runs transversely across the sole, and passing up vertically on the inner side of the heel, ends at a point about half an inch below the tip of the inner malleolus (Fig. 49, D).

In making this incision, supposing the right foot to be operated on, the surgeon holds the ankle with the palm of his left hand on the dorsum of the foot, his thumb being on the outer malleolus and his forefinger on the inner malleolus.

Entering the knife at the inner starting-point, the incision is carried down to the sole and then across the plantar aspect of the os calcis at one cut. The knife is now re-entered at the outer starting-point, and is carried down

to meet the first incision at the sole. If an attempt be made
to perform the incision at one cut, and to make the outer
limb of the incision by cutting from the heel towards the
leg, the knife may slip and cut too far up into the leg,
running by the starting-point.
On the left foot the same pre-
caution is observed, but the
incision is commenced on the
outer side.

This incision should be
carried well and cleanly down
to the bone. The heel flap is
now dissected back: the thumb-
nail of the left hand is used
with force to drag back the
soft parts, while the knife is
kept well on to the bone and
parallel to the surface of the
flap The os calcis must be
laid perfectly bare. The great
point in Syme's amputation is
to "keep close to the bone."

The flap must be cleared
from the tuberosities of the os
calcis, and then from its pos-
terior surface.

2. *The Dorsal Incision.*—
The surgeon now holds the
foot in the left hand in the
position of full extension, and
connects the extremities of the
heel incision by a cut which
simply sweeps across the front

Fig. 49.—PLANTAR INCISIONS.

A, Lisfranc; B, Chopart; C, Piro-
goff; D, Syme; E, Farabeuf's
subastragaloid amputation; F,
Farabeuf's amputation at the
ankle.

of the ankle region. The dorsal and the heel incisions
are about at right angles to one another. The cut includes
all the soft parts down to the bone. The tendons must
be cleanly divided while the foot is kept on the stretch.

3. *The Disarticulation.* — The ankle-joint is at once
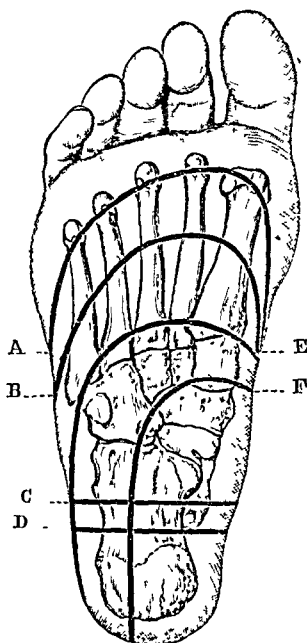exposed, the anterior ligament having been severed. The

knife is now introduced into the joint and the lateral
ligaments are divided, in both instances by cutting from
within outwards. These complex ligaments are difficult to
cut if attacked from the outer side of the articulation.
The posterior ligament is cut, the upper surface of the
os calcis is cleared, and by the division of the tendo
Achillis the disarticulation is completed.

4. *The Removal of the Malleoli.*—The soft parts are
cleared from the two malleoli and the lower end of the
tibia, great care being taken not to damage the flap. The
exposed bones are then divided by a horizontal saw-cut, the
saw being applied about a quarter of an inch above the
inferior margin of the tibia.

The flaps may be protected by spatulæ during the
sawing. If it should be necessary, the malleoli may be
held with lion forceps.

Before the wound is adjusted by sutures, a hole may be
made in the centre of the heelflap, and a drainage tube
introduced.

Hæmorrhage.—The anterior tibial artery is cut in the
dorsal flap just opposite the centre of the front of the ankle.
The external and internal plantar arteries are divided in
the inner section of the heel flap. The two vessels are close
together. The following vessels may give rise to hæmor-
rhage: the internal malleolar of the posterior tibial
behind the inner malleolus; the anterior peroneal in front
of the tibio-fibular joint; the external and internal malleolar
of the anterior tibial in front of their corresponding malleoli.
The internal saphenous vein is cut in the dorsal flap, the
external in the heel flap.

Comment.—The amputation gives admirable results, and
secures a sound and firm stump. The patient walks upon
the natural tissues of the heel. The tendo Achillis forms
an attachment with the mass of the cicatrix. With a
properly adapted boot, a patient after Syme's amputation
can walk with little appreciable lameness. .

The following special points in the operation must be
noted :—

1. It is important that the flap should be accurately

cut. In some text-books it is advised that the incision be carried from the tip of the outer malleolus to a point half an inch *behind* and below the inner malleolus. If this be done, there is great probability that the posterior tibial artery will be divided before its bifurcation, and the main artery of the flap (the internal calcaneal of the external plantar) be thus lost.

If the flap be too large, there is great difficulty in dissecting it back, and it will probably be dangerously scored and bruised in the attempt.

2. In clearing the os calcis, the periosteum may be at the same time peeled off—as many advise—and so made to form an important constituent of the heel flap. In young subjects (under the age of fourteen years) the posterior epiphysis of the os calcis may be detached and left undisturbed in the flap.

In such subjects it generally comes away during the process of clearing the os calcis. In still younger patients— say those under ten—the superficial parts of the os calcis will be found imperfectly ossified, and chunks of the soft bone may be cut away in a too vigorous clearing of the heel flap.

3. It is desirable that all the articular surface of the tibia should be removed, and, as the under surface of the bone is much domed, the section must be made as high up as a quarter of an inch to quite clear the summit of the concavity. In young patients the whole of the lower epiphysis may be removed by a too liberal use of the saw ; the measurement (quarter of an inch) refers to adults.

B.—INTRACALCANEAL AMPUTATION OF THE FOOT.

Pirogoff's Operation.—This operation closely resembles Syme's, save that the os calcis is sawn through and its hinder part is left in the heel flap. The lower ends of the tibia and fibula are sawn through, and to this cut surface of bone the surface of the divided os calcis is adjusted.

The operation usually described is a modification of Pirogoff's original procedure. Pirogoff divided the cal-

caneum vertically and left the articular surface of the tibia, unless it was diseased.

Position and *Instruments.*—The same as in Syme's operation. The saw should either be a fine Butcher's saw, or a slender saw with a movable back. Retractors are required.

Operation.—The incisions are nearly the same as in Syme's operation, with these modifications:—They com-
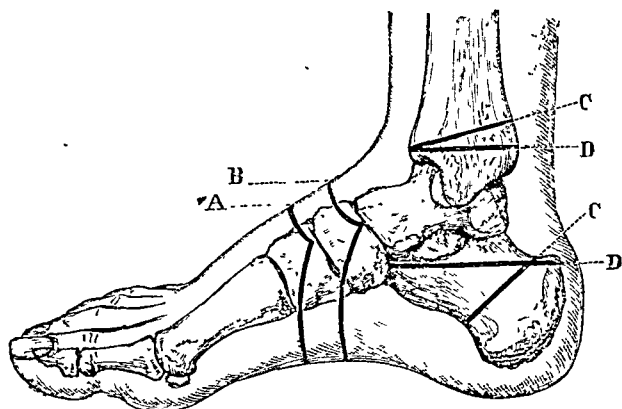

Fig. 50.—A, Farabeuf's subastragaloid amputation; B, Farabeuf's amputation at the ankle-joint; C C, Saw-cuts in Pirogoff's operation; D D, Saw-cuts in Pasquier and Le Fort's operation; D shows also the saw-cut made in the os calcis in Tripier's operation.

mence on the outer side, just in front of the tip of the malleolus, and end on the inner side a few lines in front of the internal process. The heel incision is carried a little farther forward than in Syme's operation (Fig. 49, C). It is carried well down to the bone. The soft parts are dissected backwards from the os calcis for about a quarter of an inch.

The dorsal cut is then carried out, and may be a little more convex than in Syme's amputation. The ankle-joint is opened, and disarticulation effected precisely as already described.

The foot is now dragged forward and placed in the position of full extension.

The whole of the upper surface of the os calcis is exposed. The saw is applied to this surface, one finger's-breadth behind the astragalus, and is made to cut the bone obliquely, following the lines of the now distorted heel incision. In sawing the bone, the soft parts must be carefully retracted, and, in the position in which the foot is held, the saw runs nearly vertically. The greatest care must be taken not to damage the arteries in the inner part of the heel flap.

The soft parts are now dissected from the lower ends of the tibia and fibula. The saw is applied to the anterior aspect of these bones, close to the articular surface of the tibia, and is made to cut so obliquely upwards that the saw emerges on the posterior aspect of the tibia, a finger's-breadth above the articular surface (Fig. 50, c). Any unduly long tendons are divided. The wound is sutured as in Syme's operation, the cut surfaces of bone being thus brought into close contact.

Care must be taken in the after-treatment that the heel fragment is not drawn up by the tendo Achillis.

The vessels divided are the same as in the preceding operation.

Comment.—Some surgeons make much larger heel flaps, carrying the incision forwards and downwards, so as to cross the calcaneo-cuboid joint, instead of directing it nearly vertically downwards from the malleoli.

CHAPTER XIV,

AMPUTATION OF THE LEG.

THE amputations may be dealt with in three regions :—

    A. Supramalleolar amputation.
    B. Amputation through the middle of the leg.
    C. Amputation at the "place of election."

A.—SUPRAMALLEOLAR AMPUTATION.

Methods.—The following methods of operating will be described :—

    1. Oblique elliptical incision (Guyon's operation).
    2. Large posterior flap.
    3. Teale's amputation.

Instruments.—A small amputation-knife, with a blade of about five inches ; a stout, somewhat narrow knife, with a blade four inches long, a narrow but rounded point, and a large, strong handle (this would be a modified resection knife, and is required for Guyon's operation ; it may also be used to separate the anterior or posterior flap from the bones in the other amputations); a scalpel, an amputating saw, retractors, Wells's artery and dissecting forceps, scissors, etc.

Position.—The patient lies on the back, with the foot and lower part of the leg projecting well beyond the end of the table. The surgeon should stand to the outer side of the right limb and to the inner side of the left. In performing Guyon's amputation, he may more conveniently take up his position at the foot of the table.

    1. **Amputation by Oblique Elliptical Incision** (*Guyon's Operation*).—This operation a little resembles Syme's amputation. It allows the terminal part of the

stump to be covered by the tissues of the back of the heel, and involves a low division of the bones. It can rightly be termed a supramalleolar amputation, and the medullary canals of the bones are not opened by the saw.

The incision commences in front, at a point just opposite, the line of the ankle-joint, and ends behind, over the summit of the curve of the heel.

Between these points the incision sweeps in a slightly curved manner from above downwards across the ankle. The cut on the inner side just skirts the malleolus; on the outer side it passes a little in front of the corresponding process (Fig. 51, A).

In making the skin incision the surgeon holds the foot in his left hand, and manipulates it himself.

In dealing with the right foot it is convenient to turn the foot inwards, and to commence the incision at the heel and on the outer side.

The knife then traverses the external side of the limb, and reaches the front of the ankle. The foot being now turned outwards, the incision is carried back along the inner side of the foot to the heel again. On the left side, the foot having been turned inwards, the incision may be commenced in front, and be carried back to the heel along the outer aspect of the limb. When the foot has been turned outwards, the ellipse is completed by drawing the knife from the heel to the starting-point across the inner side of the ankle.

The first incision involves merely the skin and the subcutaneous tissues. The surgeon then proceeds to dissect up the posterior or heel flap. This must include all the soft parts down to the bone. An exception may be made of the peronei tendons behind the external malleolus. They need not be disturbed, and should not be divided until a level above the ankle-joint has been reached. Great care must be taken of the vessels on the inner side of the os calcis. The tendo Achillis is cut, and the soft parts are cleared away from the bones of the leg up to a point about two inches above the tips of the malleoli. It is convenient to sit in order to dissect up the posterior flap.

The foot should now be extended, and the anterior incision carried well down to the bone, care being taken to avoid opening the ankle-joint. The soft parts on the front of the leg are dissected up to the level named.

Retractors having been adjusted, the surgeon divides the bones horizontally well above the bases of the malleoli (Fig. 51, *a*).

The posterior tibial nerve should be dissected out and removed.

Hæmorrhage.—The anterior tibial artery is divided near the anterior border of the tibia. The posterior tibial vessel is cut at the inner side of the heel flap, while the termination of the peroneal is severed at the outer side.

In the soft parts in front of the outer malleolus the anterior peroneal is divided.

2. **Amputation by a Large Posterior Flap.**— Two flaps are made, the posterior being the larger. The length of the posterior flap, when completed, is equal to that of half the circumference of the limb at the saw-line. This is after retraction has been allowed for. As the flap may be considered to lose about 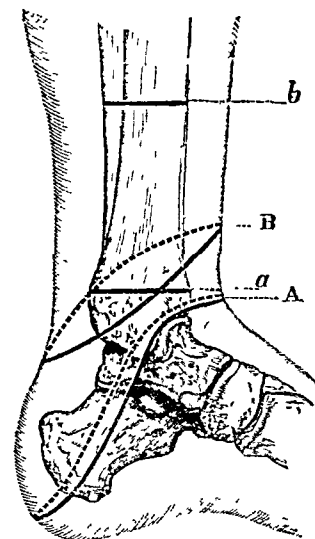one-third of its length by retraction, the posterior flap, as originally marked out on the skin, will to this extent exceed in length the measurement given.

Fig. 51.—A, Guyon's supramalleolar amputation : *a*, saw-line for that operation; B, Duval's supramalleolar amputation : *b*, saw-line for that operation.

The anterior flap is about one-fourth of the posterior. The flaps may be conveniently fashioned as shown in Fig. 54, A. The posterior flap reaches, so far as the skin limit is concerned, to about the insertion of the tendo Achillis. The internal vertical incision which limits it descends in

front of the inner border of the tibia. The external vertical incision lies behind the fibula.

(1) The surgeon stands in the position already indicated. On the right side the foot should be turned well out, and the inner vertical incision made from above downwards to the level of the insertion of the tendo Achillis. The foot being now turned inwards, the external vertical incision is made in like manner from above downwards, and meets the companion cut at the tendo Achillis insertion. On the left limb the foot may at first be turned inwards, and the cutting of the flap be commenced on the outer side. The incision should involve the skin only, and should be so made that the integuments can retract well all round. The tendo Achillis is now divided.

(2) The next step in the operation must be carefully performed. The limb having been well turned upon its outer side, an incision is made through the exposed muscles down to the tibia. This deep incision, which follows the line of the skin-cut, may be about two inches in length. It should be deepened by separating the muscles from the tibia. The limb is then turned upon its inner side, and a like incision is made down to the fibula, and the wound is deepened, as far as it extends, by separating the muscles from that bone. In this manner two deep lateral slips or gaps (*fentes*) are made down to the bones through the whole thickness of the posterior flap.

The thumb having been thrust into one of these gaps, and the forefinger into the other, the soft parts at the back of the limb can be pinched up by the surgeon's left hand. The foot is maintained in the flexed position, while the posterior flap is completed by cutting from without inwards. The posterior flap so fashioned leaves the bones and the interosseous membrane practically free.

(3) The anterior flap is now cut. The soft parts are divided down to the bones as soon as the skin has fully retracted, and are then dissected up so as to leave the bones and the interosseous membrane on this aspect of the limb practically bare also.

(4) Retractors having been adjusted and the inter-

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osseous membrane divided, the tibia and fibula are sawn
through ; the posterior tibial nerve is dissected out and
removed.

Deep sutures may be passed between the muscular
masses upon the front and back of the limb.

Hæmorrhage.—The anterior tibial artery is cut in the
anterior flap, in front of the interosseous space. The
posterior tibial and peroneal vessels are divided pos-
teriorly, the former about the middle of the flap, and the
latter in a line with the fibula. The internal saphenous
vein may be cut in making the internal vertical incision.
It usually, however, lies wholly in the posterior flap, at the
lower and inner angle of which it is found divided.

3. Teale's Amputation by a Large Anterior Flap.

—The lower third of the leg is considered to be a
particularly favourable position for the practice of Teale's
amputation.

The circumference of the limb having been taken at the
level of the future saw-line, the anterior flap is so marked
out that in its length as well as in its breadth it shall be
equal to one-half the circumference.

The posterior flap should be one-fourth the length of the
anterior flap, and will include the remaining half of the
circumference of the limb.

The lateral incisions follow the margins of the tibia
and fibula. The limits of the greater flap may be con-
veniently marked out upon the skin with ink.

The *position* of the surgeon and his assistants has been
already indicated.

The anterior flap may be commenced on the inner side
of the limb on the right side, and on the outer aspect on
the left side. The two lateral incisions should be made by
cutting from above downwards. It should be remembered
that the anterior flap is rectangular, and of the same size
all the way down.

The incision marking out the great flap should at first
concern the skin only. The incision is then deepened
down to the bones. The foot should be extended while the
tendons at the end of the flap are being divided.

The anterior flap should contain all the soft parts on the front of the limb. These should be carefully dissected up from the bones and from the interosseous membrane. The flap contains the anterior tibial artery in the whole of its length.

The posterior flap may be completed by a simple vigorous transverse cut across the back of the limb from the skin to the bones.

The foot should be flexed during this manœuvre. The

Fig. 52.—STUMP LEFT AFTER TEALE'S AMPUTATION OF THE LEG.

flaps having been retracted to a little beyond the saw-line, the retractors are applied, the interosseous membrane is divided, and the bones are sawn through.

When the wound has been closed by sutures, the stump has the appearance shown in Fig. 52.

Hæmorrhage.—The anterior tibial vessels are divided at the free lower end of the anterior flap, and at about its middle. The posterior tibial artery is found cut upon the face of the posterior flap and towards its inner side, the vessel lying between the margins of the flexor longus digitorum and flexor longus pollicis.

The peroneal vessels are divided on the outer part of this flap, close to the .fibula, and under cover of the flexor longus pollicis.

The long saphenous vein will be found in the anterior flap, the short saphenous in the posterior flap.

Comment.—Inasmuch as the leg narrows towards the ankle, it is easy, by following the general lines of the limb, to make the anterior flap too narrow below.

It is claimed for this amputation that the bones are covered by a flap which does not contain too much muscular tissue, and which possesses an artery in its entire length. It is also urged that the cicatrix is placed at the back of the stump, and is not exposed to pressure.

The operation has not been received with so much favour in other countries as it apparently enjoys in England. It is an amputation of little utility and of limited application.

The main bone to be covered at the end of the stump is the tibia. The anterior flap affords this bone in large part a covering of skin only, and the integuments on the front of the leg are usually quite thin. The anterior flap, moreover, is of very unequal thickness, containing skin only at its inner part, and a substantial mass of muscle at its outer side.

It has been pointed out that a portion of the anterior flap may be cut from the dorsum of the foot; but the tissues of that part are ill adapted to form the free end of a principal flap. The skin there is very thin, the subcutaneous tissue is scanty, and the soft parts beneath are represented almost exclusively by tendons.

It must be pointed out that Teale's amputation makes a great demand upon the structures on the anterior aspect of the limb, and involves a comparatively high division of the bones.

Further, the doubling of the artery upon itself round the end of the bone is a drawback. As a matter of fact, the resulting stump is so poorly nourished and so apt to ulcerate that in some cases no pressure whatever can be borne on it.

Of the other operations above described, it may be said in general terms that Guyon's amputation by oblique elliptical incision is the best when a low division of the bones is possible, and that the most suitable mode of amputating the leg in its lower third is by means of the long posterior flap (p. 160).

A mode of amputation by a modified circular method is shown in Fig. 53, A.

B.—AMPUTATION THROUGH THE MIDDLE OF THE LEG.

The procedure best adapted for this region is the following :—

Amputation by a Large Posterior Flap (*Hey's Operation*).

Instruments.—An amputating-knife with a blade about five inches in length ; a stout scalpel ; an amputating-saw ; retractors (the linen retractor used to protect the parts during the sawing of the bones may have three tails, the central and narrower slip being passed through the interosseous space) ; pressure forceps ; artery and dissecting forceps ; a periosteal elevator or rugine ; scissors, etc.

Position.—The patient lies upon the back, with the leg and knee beyond the end of the table. In dealing with the right limb, the surgeon stands to the outer side of the leg ; in dealing with the left limb, to the inner side. One assistant stands or sits facing the end of the table. He holds the foot and leg, and manipulates it during the operation. A second assistant stands facing the surgeon and to the left of the patient, and attends to the sponging, etc.

The circumference of the limb at the saw-line having been noted, the posterior flap is so made that its length and breadth are equal to a third of that measurement—*i.e.* are equal to the diameter of the limb.

The anterior flap is about a third of the length of the posterior one. The large posterior flap is U-shaped. The main incisions are commenced about one inch below the point at which the bones are divided. The inner limb of the U of the posterior flap is just behind the internal border of the tibia, while the outer limb of the U runs posteriorly to the peronei muscles (Fig. 53, B). These muscles are consequently found divided in the anterior flap.

(1) The operation is commenced by cutting the large flap. On the right side the limb is turned upon its outer surface (*i.e.* with that surface looking downwards), the knee is flexed, and the inner vertical incision is made from above downwards. The inner segment of the bend of the U is then completed. The leg is now turned upon its inner
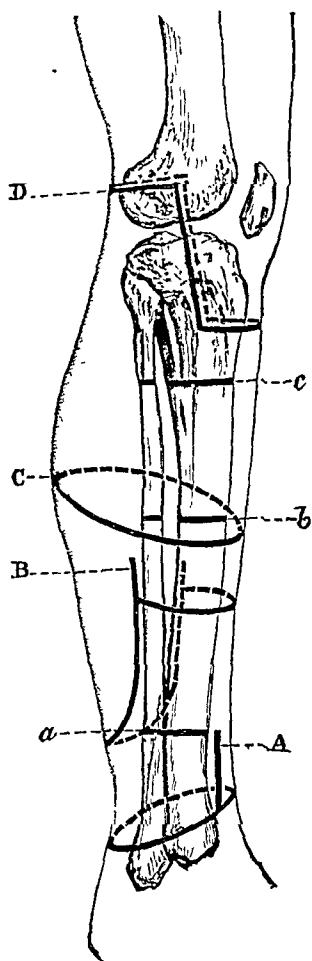
Fig. 53.—A, Modified circular supramalleolar amputation: *a*, saw-line of same; B, Hey's amputation: *b*, saw-line of same; C, Circular amputation at "the place of election": *c*, saw-line of same; D, Gritti's operation.

side, and the outer vertical incision is made by cutting from above downwards. In finishing it, the bend of the **U**, the terminal part of the flap, is completed (Fig. 53, B). On the left leg the limb may be first turned upon its inner side (*i.e.* with that surface looking downwards), and the operation commenced by cutting the outer vertical incision. The incisions thus made concern the skin only, and the integuments are well freed along all parts of the cut.

(2) The leg is now flexed upon the thigh, and the knee turned outwards so as to expose the calf. When in this position, and while the foot is flexed, the gastrocnemius muscle is picked up between the fingers and thumb and is divided transversely at the level of the retracted skin.

(3) Two short, deep, vertical incisions are now made from above downwards through the *soft parts at either margin of the* flap. These incisions extend to the bone: the inner direct to the tibia, the outer to the fibula behind the peronei muscles.

In the gaps thus made the thumb and fingers of the left hand are inserted, and the muscles of the calf, being firmly grasped, are lifted up from the bones.

The muscles are now carefully separated from the bones

along these two short lateral incisions with a stout scalpel
until the middle of the flap is entirely free, and the thumb
and forefinger can be made to meet between the deep
muscles and the bones. These muscles and the vessels they
carry with them are finally divided at their lower parts by
a vigorous transverse cut. To effect this, the amputating-
knife is introduced between the separated muscles and the
bones, and is made to cut from within outwards. The
posterior flap is now quite free below, and the soft parts
above are cleared away from the tibia and fibula and inter-
vening membrane until the level of the saw-cut is reached.

(4) The anterior flap is made by passing the knife in a
curved manner across the face of the limb. The incision at
first involves the skin only. When retraction has taken
place, the muscles are cleanly divided down to the bones.
These muscles are then dissected up as far as the level of
the future saw-cut, the interosseous membrane being thus
bared in front as well as behind.

(5) Retractors having been applied, and the interosseous
membrane divided transversely, the bones are sawn through.
The periosteum may be separated from the lower end of the
tibia.

The prominent projection of the anterior border of the
tibia should be removed with the saw in the manner de-
scribed on page 171. (*See* Fig. 55.)

The posterior tibial nerve is dissected out and removed.

Hæmorrhage.—The anterior tibial artery is divided at
the free end of the anterior flap, the posterior tibial and
peroneal vessels at the free margin of the posterior flap.
The position of these vessels has been already indicated.

C.—AMPUTATION AT THE "PLACE OF ELECTION."

The term "place of election" refers to the spot at which
the bones are divided. This point is about a hand's-
breadth below the knee-joint, and is about, or a little above,
the great nutrient foramen of the tibia. The tibia is here
still of good size, the cancellous tissue is considerable, but
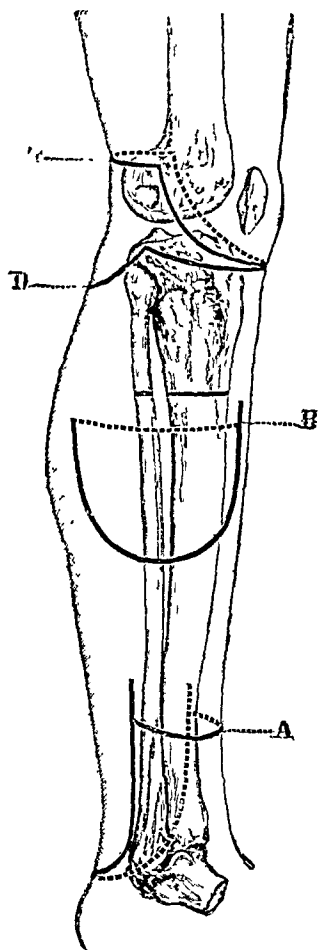the medullary canal has commenced.

Fig. 54. — A, Amputation of lower part of leg by long posterior flap; B, Amputation at the "place of election" by large external flap (Farabeuf's operation); C, Carden's amputation; D, Lister's modification of the same.

The following are the *methods* described:

1. Large external flap (Farabeuf's operation).

2. Equal lateral flaps.

1. Amputation by Large External Flap (*Farabeuf's Operation*).

Instruments.—An amputating-knife with a blade from five to six inches in length. A stout scalpel. An amputating saw. A periosteal elevator. Retractors. Six pressure forceps. Artery and dissecting forceps. Scissors, etc.

Position.—The patient lies upon the back, and is so placed that the middle of the thigh rests upon the edge of the table. The sound limb is secured out of the range of the operation.

In operating upon the right leg, the surgeon stands throughout on the outer side of the limb. In amputating the left leg, he should stand at the end of the limb, and a little to the outer side of it, while making the preliminary skin incisions. While dissecting up the flap and completing the operation, he should stand to the inner side of the limb.

One assistant is placed at the end of the limb, to manipulate the foot and leg. The

second assistant stands upon the opposite side of the limb to the surgeon, whom he faces.

Operation.—The external flap is ∪-shaped. Its length is equal to that of the diameter of the limb at the level of the future saw-line—*i.e.* is equivalent to one-third of the circumference of the leg at the same level (Fig. 54, B).

The anterior limb of the ∪ is commenced opposite to the saw-line, and in passing down the leg runs parallel with and just to the inner side of the anterior border of the tibia.

The posterior limb of the ∪ follows a line on the back of the calf diametrically opposite to the anterior limb. The posterior incision ends, however, above, at a point about 1½ inches below the commencement of the anterior limb of the ∪.

(1) The operation is commenced by marking out the external flap by a skin incision.

In the case of both the right and the left leg, the knee should be flexed and the limb turned upon its inner side— *i.e.* so turned that its outer aspect is well exposed to the surgeon. The position of the operator while making the skin incisions has been alluded to. On the right side the incision may be commenced in front, and may be completed in one sweep, the anterior wound being thus made from above downwards and the posterior from below upwards. In the case of the left limb, both of the vertical incisions can be more conveniently made by cutting from above downwards, and can be subsequently joined by the terminal curved incision.

(2) The next step in the operation is to free the skin along the whole length of the incision, so that it may retract. The integuments are merely freed, not dissected up.

(3) The limb being turned outwards, the knife is passed across the inner side of the leg, from the upper end of the posterior incision to a point on the anterior cut about 1½ inch below its commencement (Fig. 54, B). This incision is slightly curved, and involves the skin only. The integuments are lightly freed along the line of the incision.

(4) The limb being again turned with its inner surface

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downwards, the operator proceeds to dissect up the great flap, which should contain all the soft parts down to the bones.

The flap is separated along the anterior limb of the ∪ incision by cutting from above downwards down to the bone along the outer side of the anterior border of the tibia. The fingers of the left hand are thrust into the gap so made, and the tibialis anticus is separated from the bone. When the muscle is sufficiently separated, it is cut obliquely from
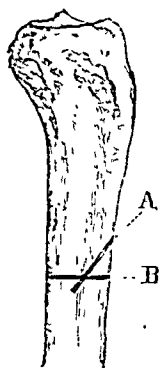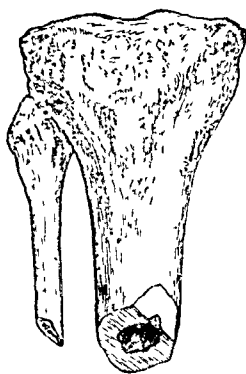

Fig. 55.—METHOD OF SAWING THE TIBIA.

Fig. 56.—METHOD OF SAWING THE BONES OF THE LEG.
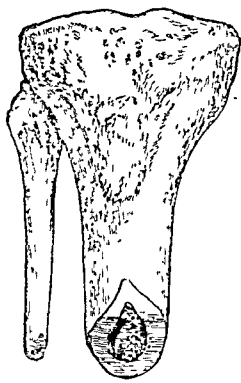
Fig. 57.—METHOD OF SAWING THE BONES OF THE LEG.

above downwards and outwards, with the result that the section of the muscle will be thin when the margin of the skin is reached.

The whole of the soft parts involved in the external flap are dissected up from the bones and interosseous membrane. In effecting this the finger and the handle of the scalpel are used more freely than the knife. The muscles should be cut obliquely at their lower extremities, so that the section of muscle close to the free margin of the skin —*i.e.* at the bend of the ∪—shall be quite thin. The anterior tibial artery is divided at the free end of the flap in making one of these oblique sections of the muscles (Fig. 58).

In dissecting up the soft parts, great care must be taken not to dissect the flap up too far. If this be done, it is possible to reach the spot where the anterior tibial artery is piercing the interosseous membrane, and to actually divide the vessel at that spot.

The future of the operation depends upon the integrity of this artery.

(5) The soft parts included in the small inner flap may now be cut by transfixion at the level of the retracted skin. The muscular tissue so divided must be in the next place separated from the bones up to the level of the saw-line. The bones and interosseous membrane should be bared. The retractors are now applied and the bones sawn through.

(6) The manner in which *the bones are·sawn* is of some importance, especially as the prominent anterior border of the tibia is apt to project into the anterior wound when the flaps have been adjusted The remarks now to be made apply to all amputations in this region.

The interosseous membrane having been incised, the periosteum covering the tibia is divided by a circular cut. This circular cut is joined from above by two lateral vertical incisions through the investing membrane. The two flaps—anterior and posterior—of periosteum thus marked out should be separated from the bone by an elevator.   If preferred, these flaps may be dissected up from the bone with the deepest layers of muscle ; or, on the other hand, the periosteum on the posterior surface of the tibia may be ignored, and only the anterior segment preserved. Some surgeons strip up the periosteum from the fibula also.

The periosteum is retracted to a point just above the saw-line.   The surgeon stands in the same position—*i.e.* to the outer side of the right leg and to the inner side of the left—and divides the fibula first. The limb is still so placed that the external surface is uppermost. In sawing the left fibula, the point of the saw is directed downwards, towards the floor.   In dividing the right bone, the point of the instrument is directed upwards, towards the ceiling.

The fibula should be divided about 1 cm. above the tibia, and the saw should pass obliquely from above downwards and inwards (Fig. 56). The saw is now entered upon the inner surface of the tibia, above the level at which the bone is to be divided. The instrument is made to cut downwards and outwards for a certain distance (Fig. 55, A). The transverse saw-cut is now made from before backwards (Fig. 55, B), with the result that the whole bone is divided, the piece marked out by the first saw-incision drops off, and the tibia presents a sloping surface on its inner side.

This method of dividing the bones is adapted to the amputations by external flap or by two lateral flaps.

Fig. 58.—APPEARANCE OF THE STUMP AFTER THE AMPUTATION OF THE LEG AT THE "PLACE OF ELECTION" BY A LARGE EXTERNAL FLAP. (*Farabeuf.*)

In the case of amputation by antero-posterior flaps or by the circular method, the fibula may be cut at the same level as the tibia, and the anterior margin of the tibia should then be removed by a sloping saw-cut, the instrument being applied in the manner just detailed (Figs. 55 and 57).

The periosteal flap or flaps having been adjusted over the divided bone, and any deep sutures having been inserted, the operation is completed by closing the surface wound.
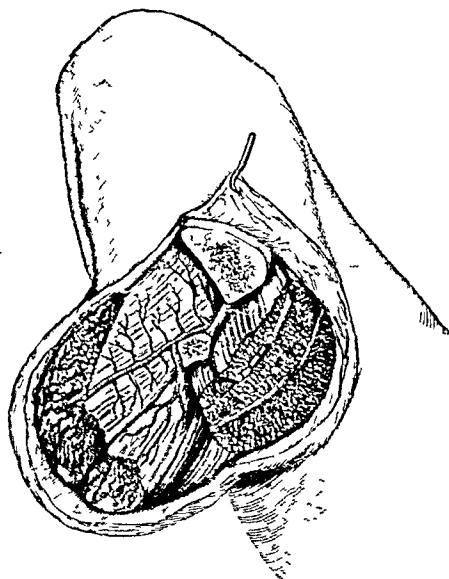
Hæmorrhage.—The anterior tibial artery is divided at

the free end of the external flap. The posterior tibial and peroneal vessels are cut close together, and lie on the same plane upon the face of the inner flap. (Fig. 58.)

Several muscular branches will require ligature notably the sural arteries connected with the gastrocnemius muscle, and the large branch from the posterior tibial artery to the soleus. The nutrient artery of the tibia will be divided at or about its entrance into the bone.

Comment.—An excellent stump results from this operation. The cicatrix comes upon its inner side and is well removed from pressure. The bones are admirably covered, and, if the operation be carefully carried out, the vitality of the great flap is ensured.

2. **Amputation by Equal Lateral flaps.**—The general shape and position of the flaps are shown in Fig. 59, A. The flaps are semilunar in outline. The anterior median incision is commenced some 2 cm. below the future saw-line, and is carried vertically downwards just to the outer side of the crest or anterior border of the tibia. The posterior incision is commenced on the back of the leg, at a point diametrically opposite to the commencement of the anterior incision.

In length each flap should slightly exceed the half-diameter of the limb at the saw-line, retraction being allowed for.

The flaps are dissected up as skin-flaps.

A little way below the saw-line the soft parts of the limb are divided transversely down to the bones. They are then separated from the bones, and the operation is completed as in amputation by the circular method. The bones are divided as shown in Fig. 56.

This operation is merely a modification of the circular amputation. It is easier to perform. The cicatrix is terminal, and is antero-posterior instead of being transverse.

CHAPTER XV.

DISARTICULATION AT THE KNEE-JOINT.

The following **methods** are here described :—

1. Disarticulation by lateral flaps (Stephen Smith's operation).
2. Disarticulation by elliptical incision (Bauden's operation.)

1. Disarticulation by Lateral Flaps.—(*Stephen Smith's Operation.*)—The flap consists of the integuments only, the posterior muscles being divided transversely about the level of the articulation.

Instruments. — An amputating-knife with a blade 5 to 6 inches in length; a stout scalpel; six pressure forceps; artery and dissecting forceps; retractors; scissors, etc.

Position.—The patient lies upon the back, and is so placed that the middle of the thigh rests upon the lower margin of the table. The sound limb is secured out of the way. The surgeon stands to the outer side of the right leg, to the inner side of the left. One assistant, placed at the extremity of the limb, holds the leg and manipulates it as required. The second assistant stands facing the surgeon, and attends to the flap, the sponging, etc.

Operation.—The flaps are of somewhat semilunar outline. The incision commences in front, in the median line, about one inch below the tubercle of the tibia. It is carried in a curved manner across the most prominent part of the outer side of the leg, and is then made to slope upwards to reach the middle line at the posterior aspect of the limb. It terminates as a vertical cut opposite the centre of the interarticular line.

A second incision begins at the same point on the front of the limb as the first, and pursues a similar direction across the inner side of the leg, meeting the first incision at the median line upon the posterior aspect of the extremity. The inner flap should be a little fuller than the outer, in order to ensure a sufficient covering for the internal condyle, which is longer and larger than the external.

The outline of the flaps is shown in Fig. 60, A.

(1) The skin incisions on both the right and the left leg are more conveniently made by cutting from behind forwards. The knife is entered at the posterior aspect of the limb, at a spot opposite to the centre of the interarticular line, and is drawn forwards, first upon one side of the limb and then upon the other, to reach the point of meeting one inch below the tubercle of the tibia.

While the outer incision is being made the limb is rotated inwards, and *vice versâ*.

(2) The skin is freed all round, and the two flaps are dissected up. They should include all the soft parts down to the tendons and muscles, which are well laid bare, but are as yet left uncut. The patellar ligament is cut as soon
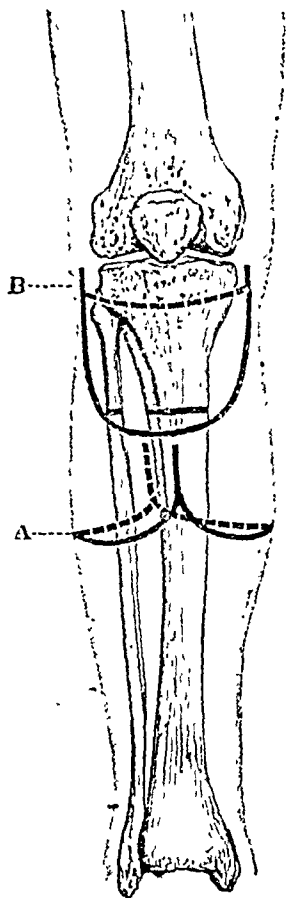

Fig. 59.—A, Amputation at the "place of election" by lateral flaps; B, Disarticulation at the knee by long anterior flap.

as it is reached, being divided against the tuberosity of the tibia.

The flaps are retracted to the level of the joint-line.

(3) An incision is now made along the extreme upper margin of the tibia. This incision, which is transverse and concerns the anterior and lateral aspects of the bone, divides everything down to the bone, including the ilio-tibial band, the tendons of the sartorius, gracilis, semitendinosus, and biceps muscles, the internal and external lateral ligaments, and, lastly, the coronary ligaments attaching the semilunar cartilages. The knife, indeed, enters the joint between the upper surface of the tibia and these cartilages, and it is in this manner the articulation is opened. In dividing the coronary ligaments the knife should be entered at the sides of the joint and not in front.
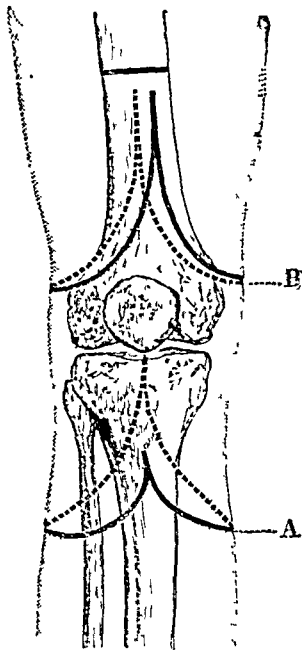

Fig. 60.—A, Stephen Smith's disarticulation at the knee; B, Amputation of the thigh by lateral flaps.

The knee is now flexed, and the two crucial ligaments are carefully divided from before backwards.

(4) Nothing remains but to divide by a vigorous transverse cut the soft parts still connecting the leg with the thigh, viz. the posterior ligament of the joint, the popliteal vessels and nerves, the popliteus and gastrocnemius muscles, and the semimembranosus or other undivided tendon of the ham.

Before making this final incision, the assistant who is retracting the flaps should compress the popliteal artery against the lower end of the femur.

Bryant advises that the condyloid origins of the gastrocnemius should be removed, but there appears to be no need for this step.

Hæmorrhage.—The popliteal artery and vein are the only vessels of any size requiring ligature. Ligatures will probably be needed for the sural arteries, the azygos artery, for branches of the superior articular vessels (especially on the outer side), and for the superficial division of the anastomotica magna (on the other side of the limb).

Comment.—This operation provides an excellent and complete covering for the condyles of the femur. When the edges of the flaps are brought together the wound looks directly downwards as the patient lies in bed. The stump, therefore, is admirably provided for in the matter of drainage.

The cicatrix lies in an antero-posterior direction between the condyles, and in process of time occupies the intercondyloid notch. Into this depression it sinks, and the prominent condyles serve to effectually protect it from pressure. It will be seen, moreover, that the scar is in time drawn towards the posterior aspect of the limb, and is thus further protected from pressure when an artificial leg is worn (Fig. 61).
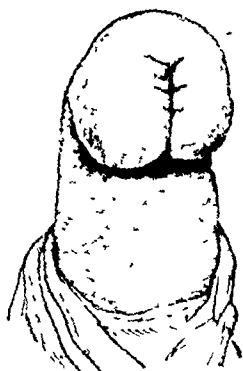

Fig. 61.—THE STUMP AFTER STEPHEN SMITH'S AMPUTATION AT THE KNEE-JOINT. (*After Bryant.*)

2. **Disarticulation by Elliptical Incision** (*Bauden's Operation*).—The *instruments* required and the *position* of the patient and the surgeon are the same as in the previous operation.

The interarticular line having been made out, the antero-posterior diameter of the limb at this line is estimated. The elliptical incision is so planned that its lowest part crosses the crest of the tibia at a distance below the joint-line equal to the antero-posterior diameter of the limb. The highest part of the ellipse reaches the median line posteriorly at a distance of half a diameter below the same line. The incision is inclined at an angle of 30 degrees (Fig. 62, A).

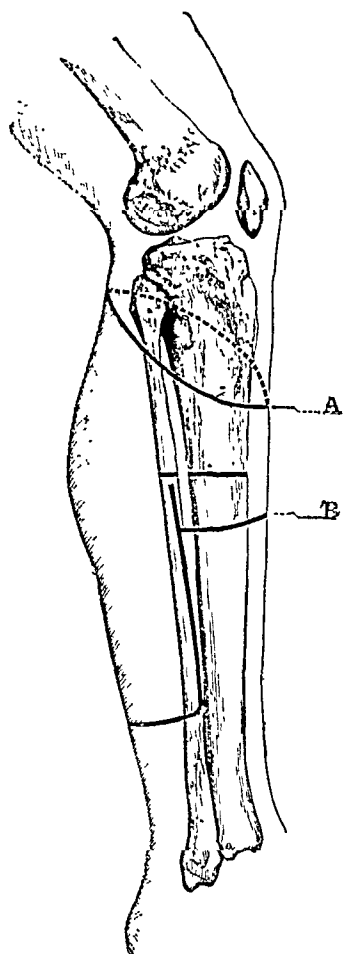The incision is carried through the integuments, which

Fig. 62.—A, Disarticulation at the knee by the elliptical method (Bauden's operation); B, Henry Lee's amputation of the leg.

are then well freed along the whole extent of the wound.

The skin on the anterior aspect of the limb is turned up in the form of a cuff, while that upon the posterior side of the leg is displaced upwards by gliding merely.

By the employment of these two methods the integuments are retracted as far as the patella, the knee-joint being kept extended during the process.

The limb is now flexed a little, the patellar ligament is divided, and the articulation is entered by passing the knife between the semilunar cartilages and the head of the tibia, as in the operation last described.

Both the patella and the semilunar cartilages are preserved.

The ligaments having been divided as already described, the soft parts at the back of the joint are severed by a circular cut with the knife, made from before backwards.

The cicatrix resulting from this operation is transverse, and is placed upon the posterior aspect of the limb. A very excellent stump is obtained.

CHAPTER XVI.

AMPUTATION OF THE THIGH THROUGH THE CONDYLES.

In this operation the femur is divided at the bases of the condyles, about the level of the tubercle for the insertion of the adductor magnus tendon, or a little above that spot. The patella is removed, except in Gritti's operation.

Instruments.—Amputating-knife five to six inches in length as regards its blade. Stout scalpel. Butcher's saw. Retractors. Six pressure forceps. Artery and dissecting forceps; scissors, etc. Lion forceps may be required.

Position.—The position of the surgeon and of his assistants is the same as in the last series of operations (page 174).

Two **methods** will be described :—

    1. Carden's operation.
    2. Modification of Carden's operation.

1. Carden's Operation.—" This operation," Carden writes, " consists in reflecting a rounded or semi-oval flap of skin and fat from the front of the joint, dividing everything else straight down to the bone, and sawing the bone slightly above the plane of the muscles, thus forming a flat-faced stump with a bonnet of integument to fall over it."

The procedure is as follows :—

(1) The incision is commenced at the most prominent part of the tuberosity of one condyle, and ends at a corresponding point on the other condyle. The cut over the front of the limb sweeps with an easy curve between these two points, and crosses the median line about the middle of the patellar ligament. The posterior incision is quite horizontal (Fig. 54, o).

The anterior cut is made first. The points of starting and ending may be marked by the thumb and forefinger. The knee-joint is a little flexed as this incision is being made. In the right limb it is commenced on the inner side, and in the left extremity on the outer side. The assistant rotates the limb as the knife passes across it.

The posterior incision is made by one single transverse sweep. Both incisions should involve at first only the skin and the subcutaneous tissue.

(2) The limb being extended, the anterior flap is dissected up, containing all the soft parts down to the patella and the capsule of the joint. The posterior "flap" may be a little freed and allowed to glide up, in order to aid the separation of the anterior flap.

(3) The knee being flexed, the joint is opened by cutting through the quadriceps tendon just above the patella. That bone is seized by the surgeon, and the anterior capsule divided on either side. The crucial and lateral ligaments are cut. With one vigorous sweep of the knife the tissues at the posterior aspect of the limb are then divided down to the bone at the level of the hinder skin incision.

A few touches with the knife serve to entirely separate the leg.

(4) The soft parts are now retracted so as to clear the bone for the passage of the saw. In dividing the femur the saw must be kept parallel to the articular surface and perpendicular to the shaft.

In young subjects regard must be had to the epiphyseal line.

Hæmorrhage.—The popliteal artery is divided close to the bone at its inner aspect. Some muscular branches may require ligature.

On the cut surface of the posterior flap will be found the two superior articular branches from the popliteal (divided close to the femur) and the anastomotica magna (on the inner side). Branches of the latter vessel and of the descending portion of the external circumflex may require to be secured in the margins of the anterior flap.

2. **Farabeuf's modification of Carden's procedure.**—This is practically a new operation. The femur is divided at the same level, but different flaps are cut. The anterior flap exceeds in length the antero-posterior diameter of the limb at the saw-line by about an inch. The posterior flap is equal to half that diameter. The lateral incisions which mark out the anterior flap commence just below the joint-line (Fig. 63). The outer cut descends on the fibula, the inner is placed about two inches behind the inner edge of the tibia. The anterior flap, therefore will occupy more than half the circumference of the limb.

The steps of the operation are precisely the same as in Carden's method. An excellent stump is provided.

The cicatrix in all these operations is found upon the posterior aspect of the limb.

We append a brief description of **amputation just above the condyles.**—*Stokes's Modification of Gritti's Method.*—In this operation the patella is retained, except its articular surface, the bone being intended to unite with the cut surface of the femur. The latter bone must be divided a finger's breadth, at least half-an-inch, above the upper limit of the condyles.

Fig. 63.—FARABEUF'S AMPUTATION THROUGH THE CONDYLES OF THE FEMUR. A, Line of saw-cut.

An oval anterior flap is made which commences at the upper and posterior angle of the condyles, and reaches to the level of the tubercle of the tibia. The skin and fascia being slightly reflected, the ligamentum patellæ and capsule are cut across and the flap turned upwards. Grasping the patella between fingers and thumb the surgeon cuts a groove for the saw all round the patella, and with a
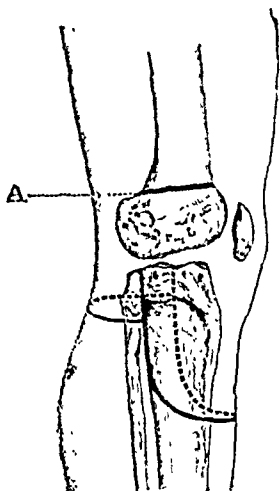
butcher's or other narrow-bladed saw removes the articular cartilage from this bone.   This is the only difficult step of the operation.

A long knife is then passed through immediately behind the femur from side to side, and is made to cut downwards and backwards at an angle of 60 degree to the axis of the limb.   The femur is sawn across a finger's breadth above the top of the condyles.   The popliteal artery and vein are secured with a few other vessels in the anterior flap.   The surfaces of the patella and femur will be found to come into apposition without tension, and to correspond closely in size.   Some operators fix the two bones with wire or sutures by drilling holes on either side, but this fixation is unnecessary.

The resulting stump is an excellent one, on which the patient can well bear a good deal of his weight.

CHAPTER XVII.

AMPUTATION OF THE THIGH.

THE operations so named concern amputation through the shaft of the femur, and occupy an intermediate position between disarticulation at the hip-joint on the one hand and the supra- or trans-condyloid operations on the other. For the most part they involve a division of the bone at or below its centre.

The following **methods** of amputating the thigh will be described :—

1. Circular method.
2. Syme's modification of the circular method.
3. By long anterior and short posterior flaps.

The comparative value of these different methods, and their applicability to different portions of the thigh, are considered on pages 187–88.

Instruments.—Large amputating-knives. (For the circular operation the blade should be about 7 to 8 inches in length, and for cutting flaps by transfixion, about 9 to 10 inches. These measurements refer to the amputation as applied to the average adult limb. In marking out skin-flaps, and in dissecting up the integuments in the circular operation, a stout knife with a broad blade 4 inches in length and a well-rounded point should be used. No attempt should be made to complete the circular amputation with one long knife. In shaping muscular flaps by cutting—as distinguished from transfixion—the stout knife with a four-inch blade should be employed. The same knife may be conveniently used to clear the bone for the saw—e.g. after transfixion flaps have been cut.) A full-sized amputation-saw. A small Butcher's saw, to shape the

end of the divided femur. A dozen pressure forceps. Artery and dissecting forceps. Retractors, scissors, needles, etc.

Position.—The patient's buttocks rest upon the end of the table. The sound leg is secured out of the way. Means should be taken to prevent the body from slipping off the table. The surgeon stands to the right of the limb in the case of either extremity.

1. **The Circular Amputation.** — Owing to the unequal manner in which the divided muscles retract, the simple circular operation is not adapted for the thigh. In order to allow for this irregular retraction, the incision must be placed obliquely.

This operation should only be carried out in the lower third of the limb. Farabeuf gives the following directions for the incision :—

On the anterior and outer aspects of the limb the distance between the level of the proposed saw-cut and the incision on the skin should be equal to one-fourth of the circumference of the thigh at the former point. On the hinder and inner aspects of the limb the skin-incision should be made a little less than half this length lower down.

In other respects the details of the operation resemble those of the circular method elsewhere.

2. **Syme's Modification of the Circular Amputation.**—By this method the circular operation is simplified. The skin is much more easily dissected up, and the integuments are less roughly handled in the process of separation.

The *operation* consists practically of the usual circular incision, with two lateral cuts to aid the retraction of the skin.

Two very short antero-posterior flaps of semilunar outline and of equal width and length are dissected up. They are composed simply of the integument and subcutaneous tissues, and consist of little more than curved incisions made across the front and the back of the thigh, each being equal to one-half of the circumference of the limb.

The skin beyond the little flaps is in its turn separated —just as in the usual circular method— and is reflected until a point is reached some two inches above the bases of the small antero-posterior flaps.

The anterior femoral muscles are now divided down to the bone by a transverse sweep of the knife at the level of the retracted skin. The posterior muscles are severed in like manner, but at the level at which they were first uncovered in forming the posterior flap.

"The muscles," as Syme puts it, "should be divided right down to the bone, on a level as high as they are exposed in front, as low as they are exposed behind."

The muscular tissue after division is further retracted, so as to clear the bone well. The femur is ultimately sawn about two inches above the level of the spot at which the anterior muscles were divided.

3. **Amputations by Long Anterior and Short Posterior Flaps.**—It is assumed that the femur is to be divided about its centre. The two flaps are U-shaped. The anterior flap is equal in length to one diameter and a half of the limb at the saw-line. The posterior flap has the length of one-half the diameter of the extremity at the same level. The anterior flap is the wider, its base slightly exceeding half the circumference of the limb (Fig. 64, A).

Operation.—(1) The limb is rotated outwards on the right side, and inwards on the left. The anterior flap is marked out first. In the right thigh the surgeon commences with the inner limb of the flap, cutting downwards. He then carries the knife across the front of the extremity, and finishes with the outer limb of the flap, the leg being now rotated inwards. In dealing with the left limb the conditions are reversed, and the cut is first made upon the external aspect. The incision includes the integuments only.

In marking out the posterior flap the surgeon's hand is beneath the thigh, and the knife, being entered at the farther limb of the anterior flap, is drawn across the posterior surface and towards the operator. This cut also involves the integuments only.

The leg is again suitably rotated as the knife passes along its course.

(2) The tissues of the anterior flap are now pinched up with the left hand, and the muscles contained therein are divided obliquely from without inwards—*i.e.,* from the skin to the bone. The soft parts are so cut that the flap is thinnest at its extremity and thickest at its base. At the latter site it will include the whole thickness of the muscular mass in front of the femur. The tissues are divided obliquely (the edge of the knife being turned towards the bone at the base of the flap), in distinction to the transverse division of parts which obtains in the circular amputations.

The muscles of the posterior flap may be conveniently cut by transfixion. They may, however, be divided in the same way as are those of the anterior flap. Transfixion is better suited for muscular limbs.

The muscles are divided well down to the bone at the bases of the flaps. The femur is barred by further retraction of the soft parts, and is sawn across at right angles to its axis.
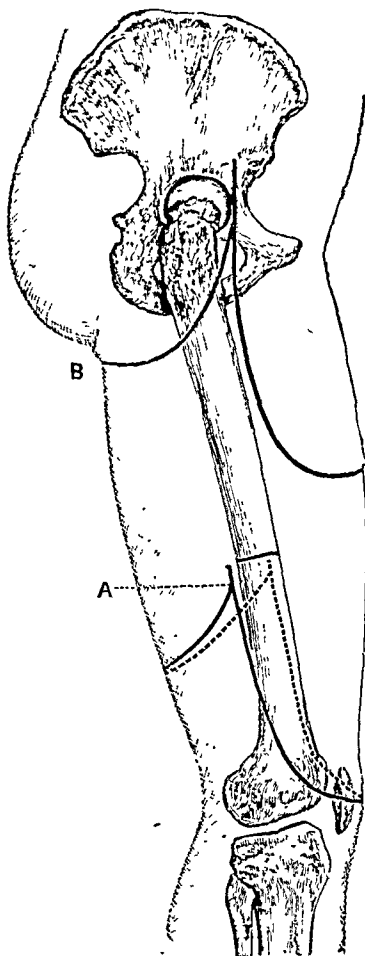
Hæmorrhage. — The

Fig. 64.—A, Amputation of the thigh by long anterior and short posterior flaps; B, Disarticulation at the hip by antero-posterior flaps.

position of the femoral artery, with reference to antero-posterior flaps generally, may be alluded to here.

In an amputation by antero-posterior flaps made above the middle of the thigh, the femoral artery, together with the profunda, will be found in the anterior flap. In a like amputation performed below the middle of the limb the main artery will be divided in the posterior flap. In this position, however, there is risk of splitting the artery if the anterior flap much exceed in width one-half of the circumference of the limb. This is avoided by placing this flap a little towards the external aspect of the limb instead of fashioning it in the median segment. When the amputation is carried out in the middle of the thigh, the anterior flap should be antero-external. This will bring the artery in the posterior flap.

The descending branch of the external circumflex artery will always be found divided in the anterior flap, together with many muscular branches. In the lower third of the limb the anastomotica magna will be divided about the inner part of the hinder flap.

In the angle between the flaps, and in the muscular tissue close to the bone, branches of the perforating arteries will be found cut.

It is needless to say that the muscular arteries in the thigh are large and numerous, and that the great veins require to be occluded by ligature.

Comment.—Owing to the uneven manner in which the muscles of the part retract, and to the extent of that retraction, a conical stump is not uncommon after any amputation of the thigh.

With regard to the *selection of methods :*—

The usual circular method cannot be advised, nor is any form of the amputation suited for the middle or higher part of the limb.

The modified circular operation described (No. 1) and Syme's operation (No. 2) are adapted for the lower third of the limb, especially in cases where a long anterior flap cannot be cut, for children, and for the limbs of enfeebled and wasted subjects. The facts that the wound-surface

is comparatively small, that the section of the muscles is reduced to a minimum, and that the main vessels are cleanly divided, are distinctly in favour of this method.

The amputation by a long anterior and short posterior flap (No. 3) is perhaps the best adapted for the thigh and all parts of it.

CHAPTER XVIII.

DISARTICULATION AT THE HIP-JOINT.

Mode of Controlling Hæmorrhage during the Operation.—Various methods have been adopted for preventing excessive hæmorrhage during this disarticulation.

1. The femoral artery may be ligatured either before the flaps are cut or during the fashioning of the flaps when the incision crosses the line of the artery, as in the method known as the "anterior racket" (page 195).

The procedure involves a little time, and, when a special incision has to be made, somewhat complicates the operation. The method, however, has many advantages. It has been urged by some surgeons that the artery is apt to be secured unnecessarily high up, and that the vitality of the main flap may be in consequence impaired, but this objection has not been confirmed by practice.

The femoral may be compressed in the flap by the fingers of an assistant, who grasps the base of the flap just before the vessels are divided. This method is illustrated in the amputation by transfixion (page 196).

Some surgeons advise digital compression of the femoral or external iliac. This can, however, hardly be carried out except in a child. The fingers are very apt to slip during the manipulation of the limb.

In all these methods it is needless to say that the securing of the femoral does not affect hæmorrhage from the branches of the internal iliac artery.

2. To prevent hæmorrhage from branches of both external and internal iliac arteries during the operation, Sir William Macewen strongly recommends manual pressure on the aorta. The assistant who does this should stand on a stool placed on the left side of the patient; by

crossing his right leg over the left one he throws the weight of his body on to his doubled-up right hand, which is made to compress the aorta at the level of the umbilicus. The pressure, which can be maintained during a long operation without undue fatigue, need only be sufficient to stop the femoral pulsation, tested by the assistant's left hand.

Several other methods to prevent bleeding have been used from time to time.

The following modes of performing this amputation will be described :—

> 1. Disarticulation   through   an   external   racket incision.
> 2. Disarticulation   through   an   anterior   racket incision.
> 3. Disarticulation by antero-posterior flaps (trans-fixion).

1. Disarticulation through an External Racket Incision.

Instruments.—A stout amputating knife with a blade some six inches in length, and with not too fine a point ; a large stout scalpel or resection knife ; an amputating-saw ; loin forceps if the bone is to be divided; artery forceps ; pressure forceps ; dissecting forceps; scissors, long needles, etc.

Position.—The body is drawn down until the pelvis rests upon the extreme lower edge of the table. The sound limb is secured out of the way. The patient is turned sufficiently over on the sound side to expose the postero-external aspect of the limb to be removed. Some care has to be taken to prevent the patient from slipping entirely off the table. The surgeon stands at the outer side of the thigh—in the case of both the right and the left extremities—and faces the patient.

In the case of the left limb it may be sometimes more convenient to stand on the inner side of the thigh between the limbs.

The assistant standing above the surgeon attends to the

tourniquet and supports the flap during the ligaturing of the vessels after the tourniquet has been removed. Another assistant manipulates the limb, while a third, standing opposite to the surgeon, attends to the sponging and assists in the disarticulation, in the fashioning of the flaps, and in securing the vessels.

The Operation.—(1) The limb being adducted and a little flexed and rotated in, the knife is entered about two inches above the upper edge of the great trochanter, and is carried vertically down the limb along the posterior border of the trochanter for about seven inches. The knife is now drawn across the limb in front and behind in the form of two crescentic incisions, which meet on the inner side of the thigh some little way below the termination of the vertical incision, and some inches below the genito-crural angle. The whole of this extensive cut should at first involve only the skin and the subcutaneous tissues. At the outer aspect of the limb the incisions form a large inverted Y. While the oblique incision is being made, the assistant may rotate the thigh a little so as to make the tissues meet the surgeon's knife.

(2) The surgeon now turns to the oblique incision encircling the thigh, and separates the skin and subcutaneous tissues all round until these parts have been raised to the extent of about two inches.

This is effected precisely as in the ordinary circular operation, the limb being rotated as required.

(3) The thigh being being now again adducted, rotated in, and a little flexed, the knife is carried well down to the femur along the whole length of the vertical incision.

The muscles attached to the great trochanter must next be divided close to the bone. The anterior, superior, and posterior borders of the trochanter should be cleared in order. The first muscle to be divided is the gluteous medius, attached to the outer surface of the process. The obturator externus tendon is apt to escape division as it dips into the digital fossa. In clearing the process the limb must be kept extremely adducted and well rotated in. A short stout knife—such as is used in Syme's amputation or in

resection operations—is very convenient at this stage.   The knife must be carried vigorously down to the bone.

The upper part of the shaft of the femur is now cleared as far as the vertical incision extends.   The soft parts must be liberally cut, care being taken that the femoral and profunda arteries are not encroached upon.

In this step the insertions of the gluteus maximus, quadratus femoris, psoas, iliacus, pectineus and upper adductor fibres are divided, together with the superior portions of the triceps femoris.   The surgeon is aided by an assistant, who draws the divided soft parts away so as to well expose the bone.

(4) The bone has now to be disarticulated.   The capsule may be divided transversely at its upper and posterior parts while the limb is in the position of extreme adduction. The anterior part of the capsule can be severed while the thigh is a little flexed.

The limb is now rotated outwards to its utmost, the joint opened, and the round ligament cut.

Everything about the upper end of the femur should now be free and ready for the final sweep of the knife.

Up to this point no vessels of any magnitude have been divided, the chief arteries concerned being the internal circumflex, some branches of the external circumflex and of the sciatic, and a few muscular vessels.

(5) Nothing now remains but to cut the muscles upon the inner side of the limb by a vigorous circular sweep of the knife at the level of the already retracted skin.   A few touches of the blade and the limb is removed.

The great vessels are at once secured.

Hæmorrhage.—In securing the bleeding points the assistant holds up the anterior part of the flap so as to well expose the whole wound surface.   Care must be taken that any tourniquet applied does not slip when the limb is removed.

The great vessels are found severed on the anterior face of the wound, close to the divided rectus, sartorius, and adductor longus muscles.

The vessels are placed one behind the other in the

following order from before backwards : the femoral artery, the femoral vein, the profunda vein, the profunda artery.

The first vessel to be sought for after the main trunks are ligatured is the internal circumflex. It will be found divided in the tissues about the inner and posterior side of the acetabulum. The branches of this artery often give much trouble. The descending branch of the external circumflex is found cut close to the inner edge of the vastus externus. The transverse branch of that artery will also probably require a ligature.

In the posterior segment of the wound the comes- nervi ischiadici is early recognised, and will require ligature.

Bleeding will occur from other branches of the sciatic artery, and from many muscular branches distributed about the surface of the wound.

Varieties of the Operation. — (a) *Furneaux Jordan's.*—Mr. Jordan gives the following description of his operation :—" A straight incision was made, and the trochanters and upper part of the shaft were freed from their muscular attachments, after which the capsule was opened. Next the shaft was cleared downwards from all its attachments for a considerable distance, and then a few free sawing movements with a long-bladed knife through the thigh, from
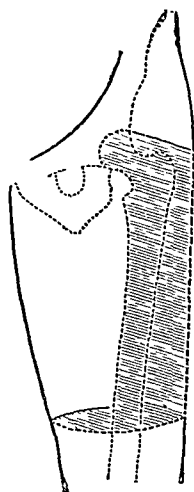

Fig. 65.—FURNEAUX JORDAN'S AMPUTATION AT THE HIP JOINT (" Surgical Enquiries," Plate X., page 288). The shaded part represents the area traversed by the knife; the dotted lines the incision.

which the bone had been removed, ended the operation. The integuments were simply drawn upwards, and the soft parts were cut straight through. No bone being left, the muscles quickly retracted, and were easily covered by the skin. Very little blood was lost. . . . The principle of the operation may be thus described :—First enucleate the bone, then cut through the limb at any desired

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spot—the middle of the thigh, or below, or even near the knee."

(*b*) *Esmarch's.*—This method is identical with that described by Veitch, Lacauchie, Volkmann, and others.

Mr. Barker gives the following account of Esmarch's operation :—

"By a single, strong, muscular sweep of the knife five inches below the tip of the trochanter, all the soft parts of the thigh are divided completely to the bone, and the latter is at once sawn across.

"The vessels are then ligatured.

"The bone is now seized in a lion forceps and steadied, while a second incision is made, commencing two inches above the tip of the trochanter, and carried down along the latter, to terminate in the first circular cut. The two borders of this incision being held apart by an assistant, the bone is cleared of the soft parts by the use of an elevator inserted under the periosteum, and by the knife where the muscle-insertions are too firm for the latter. When the capsule is reached it is divided, and the head is dislocated in the usual way."

2. **Disarticulation through an Anterior Racket Incision.**—This method is also known as the anterior oval method.

The same *instruments* are required as are used in the previous operation. In addition to those mentioned, an aneurysm needle and a small scalpel will be needed. Retractors are occasionally employed.

The *position* of the surgeon and of his assistants is the same. The patient is so placed that the pelvis rests upon the extreme end of the table and the trunk evenly upon the back.

The Operation.—(1) No tourniquet is applied. The incision is commenced at the centre of Poupart's ligament, and is carried downward along the course of the femoral vessels for about three inches. It is then made to curve inwards so as to cross the adductors about four inches below the genito-crural fold. The knife then sweeps over the posterior aspect of the thigh crosses the outer side of the

limb a little way below the base of the great trochanter,
and is carried obliquely across the anterior aspect of the
thigh to meet the vertical incision about two inches below
its point of commencement (Fig. 66).

This incision concerns at first only the skin and the sub-
cutaneous tissue. It cannot be made with one sweep of the
knife, and the limb must be so held and so rotated as to make
the tissues meet the knife.

(2) The femoral sheath
is now exposed at the
upper part of the inci-
sion, and the vessels are
laid bare by dissection.
The common femoral
artery is ligatured in two
places close together, and
is divided between the
ligatures. The femoral
vein is secured in the
same manner, and then
cut across at the same
level as the artery.

(3) The skin is freed
all round the whole
length of the incision,
and is allowed to retract
a little. The integuments,
however, are not especi-
ally dissected up.

Fig. 66.—DISARTICULATION AT THE HIP-
JOINT BY AN ANTERIOR RACKET IN-
CISION.

(4) The stout scalpel is now taken, and is carried
through the muscles in the outer flap. In this way are
divided the sartorius, the rectus, and the tensor vaginæ
femoris. The retraction of these muscles will expose the
external circumflex artery, which is secured between two
ligatures and divided.

Carry the knife backwards, rotate the limb in, and
divide the insertion of the gluteus maximus. Rotate the
limb out and divide the psoas muscle. At this point
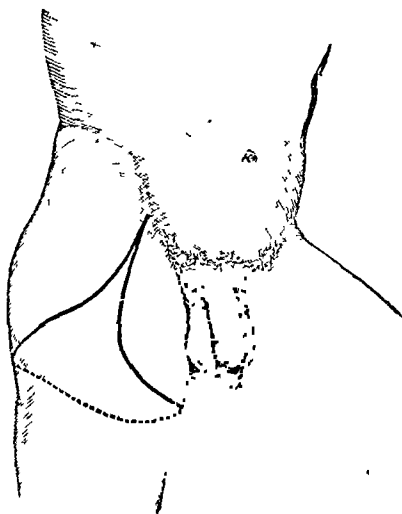the internal circumflex artery is exposed, secured, and

divided. Retractors are of use at this stage of the operation.

(5) The muscles in the inner flap are now cut at the level of the retracted skin. These include the pectineus, the gracilis, and the superficial adductors. Any divided vessels are secured.

(6) Adduct the thigh, and rotate it inwards so as to expose the great trochanter. Divide the insertions of the muscles attached to this process, notably the gluteus minimus and medius.

(7) Abduct the limb and rotate it out. Incise the capsule transversely. Disarticulate. Divide the round ligament and also the obturator externus tendon, if it has up to the present escaped division.

(8) The limb being still more rotated outwards, the head of the femur is dragged forward, and the longer knife being passed behind the bone, all the soft parts at the posterior aspect of the limb are divided with one sweep of the blade at the level of the retracted skin. These tissues will include the hamstrings, the great sciatic nerve, and the undivided parts of the adductors, principally represented by the adductor magnus.

When the wound is approximated, there should be no strain upon the sutures, which are deeply applied.

Hæmorrhage.—It is a feature of this operation that the vessels are ligatured as they are exposed, the surgeon dealing with the hæmorrhage according to the method adopted during this removal of a large tumour. In my experience of this operation the loss of blood has been quite insignificant.

3. **Disarticulation by Antero-Posterior Flaps (Transfixion).**—The great feature of the operation consists in the rapidity with which it can be performed. Fergusson states that the procedure can be completed (so far as the use of the knife is concerned) in from twelve to twenty seconds.

This was a matter of no little moment before the days of ether and chloroform.

The anterior flap is long and **U**-shaped. The posterior flap is shorter, and is more squarely cut.

No tourniquet of any kind is employed. The aorta or external iliac should be compressed by an assistant.

Instruments.—A pointed amputating knife, having a length equal to one and a half times the diameter of the limb at the level of the hip. Artery forceps. Ten or fifteen pressure forceps. Scissors, needles, etc.

Position.—The patient is supine, and the buttocks rest upon the extreme edge of the table. The sound limb is secured out of the way. The surgeon stands to the outer side of the limb in the case of both the right and the left extremity. One assistant stands above the operator. His duty is to attend to the anterior flap, to compress the main vessels as the flap is being cut, and to hold it out of the way during the disarticulation. A second assistant stands opposite to the surgeon to assist generally, and to seize any bleeding points as soon as the limb is separated. A third helper may stand near the patient's shoulders (on the opposite side), to steady the pelvis and prevent the body from slipping off the table. The fourth assistant manipulates the limb. This office is of exceeding importance. The rapidity with which the disarticulation can be effected depends largely upon the smartness of this assistant.

The limb is made to assume a different position at each step of the operation.

(1) The limb is a little flexed and a little abducted. The knife is entered midway between the anterior superior iliac spine and the top of the great trochanter, is thrust through the limb parallel with Poupart's ligament, and is brought out at the inner side of the thigh behind the adductor longus, about one inch in front and one inch below the tuber ischii, and some three inches from the anus.

The knife should graze the head of the femur in its passage, and just open the hip capsule. It is passed, therefore, as deeply as possible.

If reasonable care be not taken, the knife may slice the femoral vessels, or may be arrested by the femur, or may enter the thyroid foramen, or may have its point driven into the testicle or the thigh of the opposite side.

The surgeon now cuts, by a sawing movement of the knife, a **U**-shaped anterior flap some eight inches in length.

This flap will end about the junction of the upper with the middle third of the thigh (Fig. 64). It should include as much of the soft parts as possible.

It will be noticed that the knife is placed obliquely at the commencement of the cutting of the flap, and that it becomes transverse at the termination. More tissue has to be divided on the outer than on the inner side of the limb. If the flap be carelessly cut, it is apt to be too pointed at its extremity.

As the knife is carried downwards, the first assistant slips his fingers under the cut surface of the flap and compresses the main vessels against his thumbs, which are placed upon the skin. It thus happens that before the femoral is divided at the end of the flap the upper part of the trunk is well secured.

As soon as the flap is made this assistant draws it upwards out of the surgeon's way, while he still grasps the great vessels.

(2) The limb is straightened and is fully extended, *i.e.*, the knee is depressed. The surgeon cuts open the capsule.

The thigh is now rotated outwards. The head slips out of the acetabulum, and the round ligament is divided.

The thigh, still extended, is now rapidly adducted and rotated inwards, and the muscles about the great trochanter are cut.

The disarticulation is complete, and nothing remains but to cut the posterior flap.

(3) The whole thigh is now lifted directly up in such a way that the free end of the femur is dragged away from the posterior tissues and is forced forwards.

The surgeon passes his knife behind the femoral head and the great trochanter, and, cutting downwards, forms the posterior flap.

This flap is shorter than the anterior, and the skin is divided about the level of the gluteal fold (Fig. 64).

The clearing of the great trochanter is perhaps the most

difficult part of the operation. If it is not well done, a pocket is left in the flap at the site of that process.

Hæmorrhage.—The sciatic artery and branches of the gluteal in the posterior flap should first be secured ; then the internal circumflex, close to the inner side of the ace-tabulum. The superficial femoral is divided near to the free extremity of the anterior flap. The profunda is usually found severed about the middle of the cut surface of the flap. In the outer part of the same flap the external circumflex will be found, and will require a ligature. The femoral and profunda veins should be ligatured.

Comment.—Of these various operations, those by the *racket method* may be considered to be the best.

1. *The External Racket method* has the following points to recommend it :—

(*a*) The elastic tourniquet can be applied.

(*b*) The femur is approached through the least vascular part of the limb, and disarticulation may be effected before the main mass of the muscles of the thigh has been cut.

(*c*) The vessels of the part are divided transversely, and the main artery is severed late in the operation.

(*d*) Owing to the low position of the incision pos-teriorly, the branches of the gluteal and sciatic artery are but little interfered with, and the hæmorrhage from these vessels is comparatively trifling.

(*e*) The muscles are divided transversely, and the wound surface therefore is small. The main muscular masses are divided low down, so that in a sense the limb is removed at a point farther from the trunk than obtains in some of the other amputations, and shock is hereby diminished.

(*f*) An excellent stump is provided—*i.e.*, the ischium (the main point from which the future artificial limb will take its support) is well covered ; the cicatrix is brought to the outer side of the limb, and is as far removed from the anus as possible ; excellent drainage is provided for.

(*g*) The position of the vertical incision will permit of the hip being explored before operation, or of an excision being carried out should it be revealed that amputation is not necessary.

In *Furneaux Jordan's* operation the muscles may be divided still lower down, *i.e.*, about the middle of the thigh or near the knee.

Esmarch's method has the advantage of being rapid, and is, moreover, easily performed. The vessels are - divided and secured at an early stage of the operation. This procedure is well adapted for the application of the subperiosteal method.

2. The disarticulation through an *anterior racket incision* has many of the advantages of the previous operation, and has other special claims of its own.

3. The operation by *antero-posterior flaps cut by transfixion* has the one advantage of great rapidity of execution. Before the days of chloroform this was an advantage of the primest value.

Part IV.

OPERATIONS ON THE BONES AND JOINTS.

CHAPTER I.

OSTEOTOMY.

By osteotomy is understood the division of a bone in its continuity for the relief of deformities of various kinds.

Linear osteotomy implies the division of the bone in its continuity in a single line, usually transverse and made by the subcutaneous method.

Cuneiform osteotomy is the term applied to the cutting out of a wedge-shaped piece for the relief of such deformity as that represented by the curved tibia met with in rickets.

Osteotomy with resection of part of the shaft of a long bone is done occasionally to bring two unequal limbs approximately to the same length.

Instruments Employed.—The following are the instruments required in these operations:—(1) An ordinary scalpel; (2) chisels and osteotomes of various sizes; (3) mallet; (4) sand bag, or large block with plane surfaces; (5) blunt hooks.

The *Chisel* has the same form as the ordinary carpenter's chisel. It is square at the end, and has a very sharp edge. It should be made of the finest steel, and be very carefully tempered. The part of the instrument near the cutting edge is alone raised to a great degree of hardness; the rest of the blade is kept softer, so that there shall be no danger of its snapping. The edge is bevelled on one side only, according to the ordinary pattern, and the thickness of the blade at the base of the bevel is

H*

about one-twelfth of an inch.   Chisels with unduly thick
blades are clumsy, and are apt to splinter the bone.

It is desirable that the blade and the handle be made
of one piece of metal; that the handle be octagonal, for
convenience of holding; and that the head be rounded,
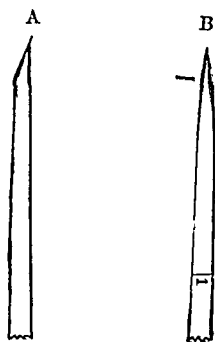smooth, and projecting, to receive the blows of the mallet.

Fig. 67.—SECTION (A)
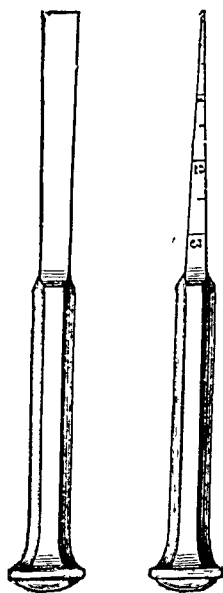OF CHISEL AND (B)
OF OSTEOTOME.
(Both actual size.)

Fig. 68.—MACEWEN'S
OSTEOTOME.

Macewen's osteotome has a wedge-shaped extremity,
and has the outline, as seen sideways, of an attenuated
double-inclined plane (Figs. 67 and 68).   It is square at the
end, has a sharp edge, and is tempered in the same way as
the chisel.

The *Mallet* should be made of metal (lead) throughout,
for purposes of sterilisation.   The heavier the head the
better.

The *Sand Bag* or *Sand Pillow* is used for the purpose

of fixing or embedding the limb during the process of dividing the bone with the osteotome.

A block of metal such as a leaden weight with rect-angular sides will be found very useful instead of the sand-bag. It should be encased in a sterilised towel, and when placed transversely it forms a good fulcrum on which to complete the fracture of the bone after it has been nearly chiselled through.

THE OPERATION.

Linear Osteotomy with the Osteotome.—The limb having been firmly embedded in a sand pillow in a suitable position, a simple incision is made down to the bone. This cut should be of·sufficient size to admit the largest osteotome intended to be used. It should be so placed as to avoid structures of importance, should be through the least vascular part of the limb, and should reach the bone by the most direct route.

Before the knife is withdrawn the osteotome may be introduced by its side, the knife acting as a guide.

Some surgeons make the skin wound correspond in direction and position with the intended wound in the bone; others place the surface incision at right angles to the future bone cut, and turn the osteotome, after that instru-ment has been introduced. The former method is the better.

The osteotome is driven through the bone with the mallet, cutting in various directions, until the bone is divided. The edge should be directed from any neighbour-ing great vessels. As the cut in the bone becomes deeper, finer osteotomes may be used.

The osteotome should be grasped firmly in the left hand, steadied by the inner border resting on the patient's limb. The surgeon ought to cut to, instead of from, him-self; thus, if the surgeon is operating on the inner side of the left limb, he ought to stand on the left side of the patient, and cut towards himself.

This operation should never be attempted until the surgeon has gained quite an extensive experience by opera-ting upon animals' bones, which should be quite fresh, and

be embedded in a sand-bag, and by performing osteotomies upon the cadaver.

Cuneiform Osteotomy.—In this form of the operation a cuneiform or wedge-shaped piece of bone is removed to remedy an abnormal curve or angular deformity. It has been applied in the treatment of the curved femora and tibiæ resulting from rickets, in some cases of bony ankylosis at an unusual angle, and in a few examples of angular deformity produced by malunion after fracture.
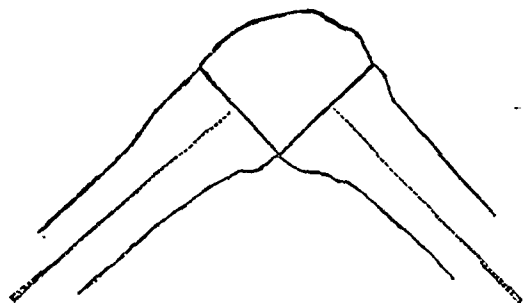
. The exact size and shape of the wedge must be carefully

Fig. 69.—Diagram to show the Lines of the Chisel Cuts in Cuneiform Osteotomy for Angular Deformity after Fracture, etc.

determined, and must obviously depend upon the position and extent of the deformity.

In general terms, it may be said that the sides of the wedge should be at right angles to the axis of the bone respectively above and below the seat of the operation (Fig. 69). In actual practice, however, so large a wedge-shaped piece of bone is very seldom removed. If the curvature in the bone be not extreme, many surgeons content themselves with a mere linear osteotomy, leaving a gap between the divided ends when the limb has been adjusted, which gap appears to fill up without complication.

In the severer kinds of deformity a wedge may be removed much smaller than is necessary to entirely overcome the deviation, a gap of moderate size being left when the limb has been brought into its normal position upon a splint.

The wedge, moreover, need not extend through the entire thickness of the bone. It may involve possibly three-fourths of the diameter of the bone, the remaining fourth being bent or broken.

In performing this operation a chisel will be found to be more convenient than a saw.

In some forms of bony ankylosis of joints, however, the saw may prove to be the more suitable instrument, or both saw and chisel may be used together.

The incision in the soft parts must of necessity be comparatively large—as large at least as the base of the intended wedge. It need be no larger, since the skin can be displaced in one or other direction according to the position of the chisel.

As soon as the bone is exposed, the periosteum must be divided and carefully separated with the elevator.

In dividing the bone the chisel should be employed and not the osteotome.

The instrument must be so held that the straight edge is towards the bone to the left, and the bevelled edge towards the portion to be removed.

If a large wedge has to be removed, it should be dealt with in sections. A small wedge-shaped piece should first be taken out, and then thin slices of bone should be shaved from each side of the exposed bone until a cuneiform cavity of the desired size and shape has been produced.

If an attempt be made to remove a large wedge at once, it will be found that the chisel is apt to go awry, to incline towards the straight edge, and in consequence an uncertain division of the bony tissue is made.

It is not well to attempt to prise out the wedge of bone with the chisel. The bone so treated is apt to split, or the chisel may be broken. The wedge can be removed better with forceps aided by an elevator.

After the bone has been dealt with, the periosteal flaps may be brought together by a few fine catgut sutures. The skin wound should not be too completely closed, but room shall be left for drainage.

CHAPTER II.

Osteotomy for Faulty Ankylosis of the·Hip-joint.

This measure is carried out in certain cases of rigid anky-losis of the hip-joint, resulting from disease, in which the limb has assumed a faulty position and all milder methods of treatment have failed. In the most usual deformity the thigh is flexed, adducted, and a little rotated in. The object of the operation is to bring the limb straight. The possibility of securing a movable joint at the same time may or may not be contemplated by the operator.

1. **Through the Neck of the Femur** (Fig. 70, A). This operation is best performed with the osteotome.

The Operation.—The patient lies upon the sound hip, and the surgeon stands to the outer side of the limb. An assistant steadies the thigh and pelvis.

A longitudinal incision about three-fourths of an inch in length is made just above the great trochanter and in the axis of the neck of the bone. The knife is carried well down to the bone. The osteotome follows the knife, and on reaching the femur is turned on its axis so that its cutting edge is at right angles to the axis of the neck.

A few blows from the mallet will suffice to divide the bone. These operations as here described are carried out by the subcutaneous method; but, as has been already ob-served, the surgeon need not be sparing of his incision, nor of the exposure of the deeper parts, if only he has taken care to avoid the possibility of wound infection.

2. **Through the Shaft of the Femur below the Trochanters.**—The osteotomy is carried out precisely as in the procedure just described.

The incision is longitudinal, is placed over the outer

aspect of the femur, and about at the level of the lesser trochanter.

The osteotome is introduced, and the bone is divided immediately below the lesser trochanter and in a line at right angles to the shaft of the femur (Fig. 70).

Comment.—In these situations the bone should be divided completely. It should not be partially cut through and then fractured, lest dangerous splinters of bone be produced. The assistant therefore should be careful how he holds the limb, and how he brings pressure to bear upon the parts which are being divided.

Fig. 70.—OSTEOTOMY FOR FAULTY ANKYLOSIS OF THE HIP.

A, Intracapsular; B, Extracapsular.

Of the two methods described— viz. that of division of the neck, and that of division of shaft—the latter may be said in general terms to be the better. It is certainly the simpler and the easier operation.

CHAPTER III.

Osteotomy for Genu Valgum.

Anatomical Points.—In the severer forms of genu valgum—and it is in these only that osteotomy is practised —there is a great increase in the size and depth of the internal condyle. This is due— as has been shown by Mickulicz —to an increase in the diaphysis of the bone rather than in the epiphysis (Fig. 71).

Fig. 71.—VERTICAL SECTION OF THE LOWER END OF A DEFORMED FEMUR, FROM AN EXTREME CASE OF GENU VALGUM.

A, Line of epiphysis; B, Transverse line drawn at level of adductor tubercle; C, Line of Macewen's operation.

The epiphyseal line is about on a level with the tubercle for the adductor magnus tendon. The trochlear surface of the femur belongs to the epiphysis.

A transverse section of the femur about the epiphyseal line will show that the outer part of the bone is much more extensive than the inner part, and this disproportion is continued for some little distance upwards in the less expanded part of the bone (Fig. 72). The medullary canal ceases some way above the point at which the shaft of the bone widens out to form the condyloid extremity. Indeed, none of these operations concerns the canal.

The following operations will be described :—

1. Osteotomy of the shaft of the femur from the outer side

2. Macewen's supracondyloid operation.

1. **Osteotomy of the Shaft of the Femur from the Outer Side.**—The patient lies upon the back, with the knee flexed over a sand bag, upon which the limb is made to rest securely. The surgeon should stand to the inner side of the limb—*i.e.*, between the patient's legs. An assistant standing opposite to him steadies the limb.

The thigh being adducted so as to well expose the outer surface to the operator (as he stands to the inner side of the knee-joint), an incision about one inch in length is carried down to the bone at a point about two inches above the external condyle. The incision is made upon the outer side of the thigh, is transverse—*i.e.*, at right angles to the long axis of the femur—and may be made in one cut. The knife passes through the
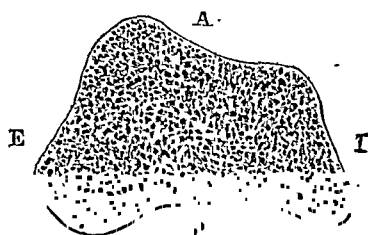

Fig. 72.—TRANSVERSE SECTION OF THE FEMUR ABOUT THE LEVEL OF THE EPIPHYSEAL LINE, SHOWING THE TRIANGULAR OUTLINE OF THE BONE.

A, P, E, I, Anterior, posterior, external, and internal surfaces.

ilio-tibial process of the fascia lata, and runs in front of the biceps muscle.

When the knife is withdrawn the osteotome is inserted, and the limb—no longer adducted—is firmly planted upon the sand bag. The osteotome is made to traverse the shaft transversely. As the outer part of the bone is here thicker than the inner part, it will be found that when two-thirds of the shaft have been divided the bone can usually be quite readily fractured.

It is essential that the division be extensive enough, and that no premature and violent attempts be made to complete the division of the bone.

2. **Macewen's Supracondyloid Operation.**— The patient lies upon the back, close to the edge of the

table. Both hip and knee are flexed ; the thigh is abducted and rests upon its outer side. The knee is well fixed upon the sand-pillow. The surgeon places himself upon the outer side of the limb.

A sharp-pointed scalpel is introduced on the *inside* of the thigh, at a point where the two following lines meet— one drawn transversely, a finger's-breadth above the superior tip of the *external* condyle, and a longitudinal one drawn half an inch in front of the adductor magnus tendon. The scalpel here penetrates at once to the bone, and a longitudinal incision.(Fig. 73, A) is made, sufficient to admit the largest osteotome. Before withdrawing the scalpel, the osteotome is slipped by its side until it reaches the bone.

The scalpel is withdrawn, and the osteotome, which was introduced longitudinally, is now turned transversely in the direction required for the osseous incision (Fig. 73, B).

The osteotome is then driven through the bone in various pre-arranged directions until the division is nearly complete.

After a certain amount of the bone has been divided, a finer instrument may replace the one first employed.

It is desirable to complete all the work intended by any one osteotome before removing it from the wound.

When the operator thinks that the bone has been sufficiently divided, the osteotome is laid aside and a sterilised sponge is placed over the wound. While the surgeon holds the sponge, he at the same time employs that hand as a fulcrum ; with the other he grasps the limb lower down, using it as a lever, and jerks if the bone be hard, or bends slowly if the bone be soft, in an inward direction, when the bone will snap or bend as the case may be.

Neither sutures nor drainage-tubes are required.

Comment.—The highest part of the articular surface of the femur is a good guide to the level of the lowest part of the incision.

Great care must be taken that the line of the bone incision is appreciated and accurately followed.

For a short distance above the condyles the femur has a much thicker outer than inner border; in many instances the outer is twice as thick as the inner.

If the form of the bone be not borne in mind, the surgeon may think that he has divided it sufficiently, and yet he may find that it will not yield, owing, in most cases, to the posterior and outer part remaining intact.

In young subjects up to fifteen or sixteen, the division of the internal two-thirds of the bone will usually suffice, the remainder being broken; but in adults, especially when the bone is hard and brittle, the section should be more complete, and as little fracturing should be attempted as is possible.

In children one osteotome will suffice for the division of the bone.

If care be not exercised, it is possible for the femur to be split longitudinally.

The incision employed is above the level of the articular ligaments.

The cut in the soft parts may be made transversely, and be so

Fig. 73. — MACEWEN'S OPERATION FOR GENU VALGUM.

A, Skin incision; B, Osteotome incision; C, Epiphyseal line; D, Inner condyle.

placed as to correspond to the intended bone incision. By this means the osteotome is more readily introduced and more easily re-inserted should it be accidentally removed during the operation. The transverse incision spares the soft parts from a certain amount of bruising and disturbance, but it does not favour so complete a subcutaneous method.

Although the synovial pouch of the knee-joint reaches as high as the level of the bone incision, it is not in the way of the actual wound itself, since it tapers to the middle line
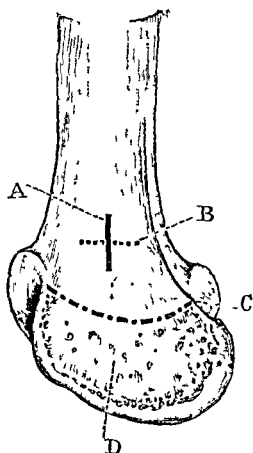
as it ascends.   A certain amount of fat intervenes between the synovial pouch and the bone, and the osteotomy cut is posterior to the pouch.

The wound is above the superior internal articular artery, and below and anterior to the anastomotica magna. Bleeding from this vessel has, however, been reported as occurring during the operation.

CHAPTER IV.

Cuneiform Osteotomy for Inveterate Club-Foot.

In this operation a wedge-shaped piece of bone is removed from the outer side of the foot at the site of the medio-tarsal joint.

Size of the Wedge.—The dimensions of the portion of bone removed must of necessity depend upon the degree of the deformity. In talipes equino-varus the base of the wedge is at the outer side of the foot, and is mainly represented by the cuboid; the apex will be at the scaphoid bone, the distal side of the wedge will be represented by a line at right angles to the metatarsal bones, and the proximal side by a line at right angles to the long axis of the os calcis.

An important addition to the removal of the wedge consists in a simple division of the neck of the astragalus, performed through a separate incision on the inner side of the latter. Perfect position of the foot can be secured by this combined operation.

In some instances the wedge is composed of portions of the astragalus, os calcis, scaphoid, and cuboid—the last-named bone predominating. In rarer cases it is found to contain portions of every one of the tarsal bones and the bases of the four outer metatarsal bones also.

Operation for Talipes Equino-Varus.—The patient is placed upon the back, with the hip and knee a little flexed, and the sole of the foot resting upon a sand pillow on the table. The surgeon stands to the outer side of the limb, and an assistant opposite to him grasps the foot and leg, and steadies the extremity or moves it as required. The operation is usually carried out as follows :—

The outer surface of the foot having been well exposed,

and the cuboid defined, an oval piece of skin is excised from
the outer side of the foot over that bone. The long axis of
the oval will be in the long axis of the foot, and will be
equal in extent to the base of the wedge of bone to be
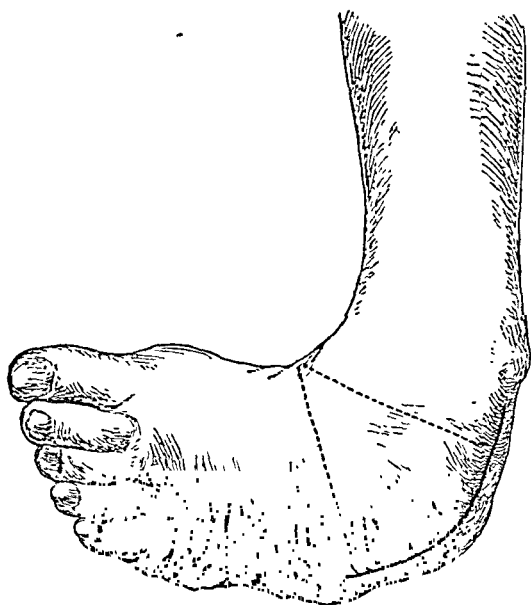removed. This piece of skin will include the mass of

Fig 74.—EXTREME TALIPES VARUS, WITH DEFORMITY OF BONES OF
TARSUS.
The black line indicates the outer incision, the dotted lines the
wedge of bone to be removed.

thickened epidermis and the bursa which are usually found
over the cuboid.

The inner side of the foot is now exposed, and at the
"stereotyped crease of skin," and in a line over the
astragalo-scaphoid joint, a vertical cut is made (from
dorsum to sole) of sufficient length to include the thick-
ness of the scaphoid bone. At this incision will fall the

apex of the wedge ; its base is represented by the part from which the skin has been already removed.

The foot is now firmly fixed so as to bring the dorsum well into view, and with an elevator the tendons and all the soft parts are raised from the dorsum of the tarsus. The elevator is introduced through the outer incision, and the surgeon works from without inwards. The instrument must be kept close to the bone, and the area to be represented by the wedge must be laid entirely bare.

In the same way the tissues are cleared from the under surface of the tarsus as far as possible, so that with the chisel or osteotome a bony wedge can be cut. This wedge has its base outwards and the apex at the scaphoid bone (Fig. 74). The wedge, being grasped by lion forceps, is further cleared with the scalpel and elevator and prized outwards. The operator pays no attention to the exact bones removed—which will include the cuboid and parts of the cuneiform. .

The wedge can usually be lifted out in one piece. Any hæmorrhage having been dealt with, the portions of the foot are brought together ; and if the deformity be not fully corrected, the neck of the astragalus should be divided transversely through an incision made on the inner side.

The large gap should now be well washed out by a stream of sterilised water from a suitable irrigator. In this way all bone dust and *débris* are removed.

The wounds are closed with sutures, and a drain may be introduced into the lower parts of the external wound.

CHAPTER V.

Excision of Joints and Bones.

General Considerations.—By the term "excision of a joint" is implied the removal of the articular extremities of the bones entering into the formation of the joint, together, necessarily, with the cartilage and synovial membrane, the procedure being carried out with the least possible amount of injury to the surrounding soft parts.

This definition, while it applies precisely to the usual excisions of the knee and elbow, is allowed also to include the usual excisions of the hip and shoulder in which only the articular extremity of the long bone forming the joint is completely removed.

By excising a joint it is often possible to preserve a limb which, but for this operation, would be subjected to amputation.

The excision of a bone may apply either to the complete removal of a bone together with its articular extremity, *e.g.* the inferior maxilla; or to the removal of a portion of a bone, *e.g.* the diaphysis of the humerus, or the acromial end of the clavicle.

Instruments Employed.—The following is a list of the instruments that may be required in an excision operation :—

Scalpels.   Bistouries (blunt and sharp pointed).
Dissecting and artery forceps.   Pressure forceps.
Scissors.   Bone forceps.   Sequestrum forceps.
Probes ; directors.
Excision knives.
Ivory or metal spatulæ.   Retractors of various kinds.
Lion forceps.
Periosteal elevators.   Rugines.

Saws of various kinds.
Chisels and mallet.
Bone gouges.　Sharp spoons.

General Conditions of Excision Operations.
—In performing excision of a joint, the following general
points are to be observed :—

1. The whole of the diseased tissue must be removed.

2. The amount of the bone removed must be limited by
such common surgical requirements as are necessary to
ensure the prospect of a useful—or, at least, not utterly
useless—limb.

3. The soft parts must be as little disturbed as possible.

4. It is important in young subjects that the active
epiphysis be not destroyed, lest a greatly shortened limb
result—a matter of infinite consequence in the lower
extremity.

5. The bones must be so divided as to be adapted to
the purposes of the new articulation, or be favourable for
ankylosis in a good position.

**The Open Method and the Subperiosteal
Method.**—The excision of a joint may be carried out by
either of the two methods just named.

The Open Method.—In the open method the bones are
exposed through the simplest and most direct incision ; the
soft parts are disturbed as little as is possible ; any tendons
which may be attached to the bones to be excised are not
cut through, but are peeled off or separated from their
point of attachment.　The ligaments of the joint, or certain
of them, can hardly escape division.

The bones are protected, and are sawn off, but no care
is taken to separate and preserve the periosteum which is
attached to them.

The Subperiosteal Method.—In the subperiosteal method
the articular ends of the bones are exposed, probably
through a similar incision to that observed in the open
method.　The object of the operator, however, is to save
if possible the whole of the periosteum of the involved

district, and at the same time to preserve the capsular ligament intact.

The osseous tissue to be removed is shelled out from within this investment of periosteum and ligament. The capsule, and the periosteum into which it extends above and below, are divided in one vertical incision. The gap made is enlarged; the bones are decorticated; they are stripped of periosteum, but at the same time the con-
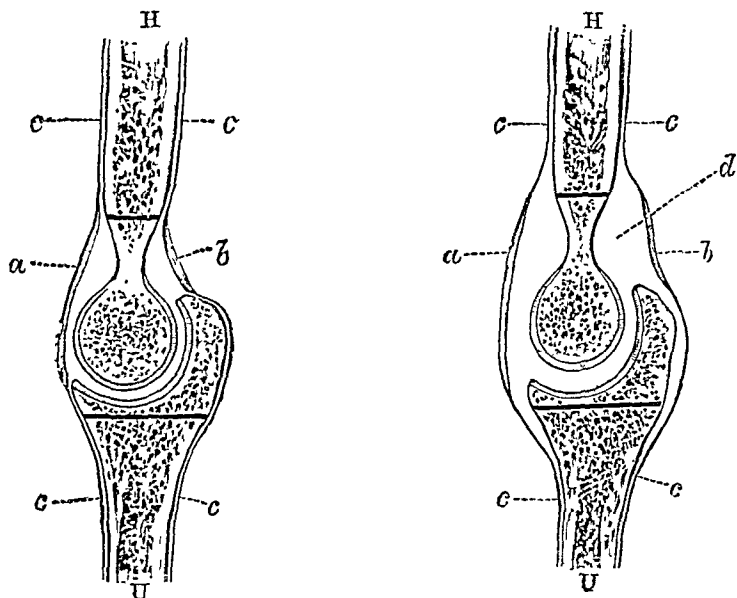

Fig. 75.—DIAGRAM TO ILLUSTRATE THE SUBPERIOSTEAL METHOD OF RESECTION.

H, Humerus; U, Ulna; *a*, Anterior ligament; *b*, Posterior ligament; *c*, Periosteum; *d*, Capsulo-periosteal sheath separated by the rugine. (The lines of the saw-cuts are shown.)

nections between that membrane and the capsule of the joint are not disturbed.

Advantages and disadvantages of the Subperiosteal Method.—The advantages claimed for the subperiosteal method are the following:—

(*a*) The periosteum being preserved, new bone is formed to replace that which has been removed.

(*b*) The capsule of the joint is preserved, and the connections of the ligaments are not severed; the new articulation is therefore likely to be all the stronger.

(c) The connections of the tendons with the periosteum are not disturbed, and greater muscular strength is consequently given to the new joint.

(*d*) There is much less hæmorrhage, the chief area of the operation being subperiosteal.

(*e*) Planes of connective tissue are not opened up, and the cavity left after the removal of the bones is limited and circumscribed by the capsulo-periosteal sheath.

With regard to these claims, there is no doubt but that, in favourable circumstances, a large quantity of new bone is produced to make good that lost by the operation.

The importance of the periosteum in this connection would appear to be paramount, although some recent writers have adduced evidence in support of the view that the bone-forming functions of the periosteum have been over-estimated.

The preservation of ligaments and tendinous connections is another advantage of this method—an advantage that is substantial and definite.

The disadvantages of the subperiosteal operation cannot, on the other hand, be overlooked.

The measure is admirable in theory, but it does not always assume so immaculate a position in practice.

In the first place the operation is often impossible.

The detachment of the periosteum is difficult and tedious. The student who attempts a subperiosteal resection for the first time upon the cadaver will find, especially if the subject be old, that the periosteum is not so substantial a membrane as is sometimes represented, and that its separation is a matter of considerable mechanical difficulty.

The operator who blindly persists in following this method will often find that, after much valuable time has

been exhausted, he has bared the bone of periosteum, but has left that membrane in shreds and holes.

In young subjects the periosteum is thicker, more active, more substantial, and more easily stripped off. It may also be said that it is more precious, and is in more need of being preserved.

In cases attended by chronic inflammation the periosteum is generally very easily detached, but in such a condition it is often of doubtful value.

It may be said, in conclusion, that the subperiosteal operation is excellent in theory, but is only excellent in practice in a few selected cases.

CHAPTER VI.

EXCISION OF THE WRIST.

THIS operation, when complete, consists in the removal of the whole of the carpus, the lower ends of the radius and ulna, and the articular extremities of the metacarpus.

Lord Lister's Operation.—This may be taken as a good example of the open method of excision, as distinguished from the subperiosteal plan.

The operation is thus described by Mr. Jacobson, the radial incision being made as in Fig. 76 :—" The outer incision is planned so as to avoid the radial artery, and also the tendons of the extensor secundi internodii and indicis. It commences above, at the middle of the dorsal aspect of the radius, on a level with the styloid process. Thence it is at first directed towards the inner side of the metacarpo-phalangeal joint of the thumb, running parallel in this course to the extensor secundi internodii ; but on reaching the line of the radial border of the second metacarpal bone it is carried downwards longitudinally for half its length, the radial artery being thus avoided, as it lies a little farther out. These directions will be found to serve, however much the parts may be obscured by inflammatory thickening. The tendon of the extensor carpi radialis longior is next detached with the knife, guided by the thumb-nail, and raised, together with that of the extensor brevior, also cut ; while the extensor secundi internodii, with the radial artery, is thrust somewhat outwards. The next step is the separation of the trapezium from the rest of the carpus by cutting forceps applied in a line with the longitudinal part of the incision, great care being taken of the radial artery. The removal of the trapezium is left till the rest of the carpus has been taken away, when it can be dissected out without much difficulty,

whereas its intimate relations with the artery and neighbouring parts would cause much trouble at an earlier stage.

" The hand being bent back to relax the extensors, the ulnar incision should next be made very free, by entering the knife at least two inches above the end of the ulna immediately anterior to the bone, and carrying it down between the bone and flexor carpi ulnaris, and on in a straight line as far as the middle of the fifth metacarpal bone at its palmar aspect. The dorsal lip of the incision is then raised, and the tendon of the extensor carpi ulnaris cut at its insertion, and its tendon dissected up from its groove in the ulna, care being taken not to isolate it from the integuments, which would endanger its vitality. The finger extensors are then separated from the carpus, and the dorsal and internal lateral ligaments of the wrist-joint divided, but the connections of the tendons with the radius are purposely left undisturbed.

" Attention is now directed to the palmar side of the incision. The anterior surface of the ulna is cleared by cutting towards the bone so as to avoid the artery and nerve, the articulation of the pisiform bone opened, if that has not been already done in making the incision, and the flexor tendons separated from the carpus, the hand being depressed to relax them. While this is being done, the knife is arrested by the unciform process, which is clipped through at its base with pliers.

" Care is taken to avoid carrying the knife farther down the hand than the bases of the metacarpal bones, for this, besides inflicting unnecessary injury, would involve risk of cutting the deep palmar arch. The anterior ligament of the wrist-joint is also divided, after which the junction between the carpus and metacarpus is severed with cutting pliers, and the carpus extracted from the ulnar incision with sequestrum forceps, and by touching with the knife any ligamentous connections.

" The hand being now forcibly everted, the articular ends of the radius and ulna will protrude at the ulnar incision. If they appear sound, or very superficially affected, the

articular surfaces only are removed.   The ulna is divided
obliquely with a small saw, so as to take away the cartilage-
covered rounded part over which the radius sweeps, while
the base of the styloid process is retained.   The ulna and
radius are thus left of the same length, which greatly pro-
motes the symmetry and steadiness of the hand, the angular
interval between the bones being soon filled up with fresh
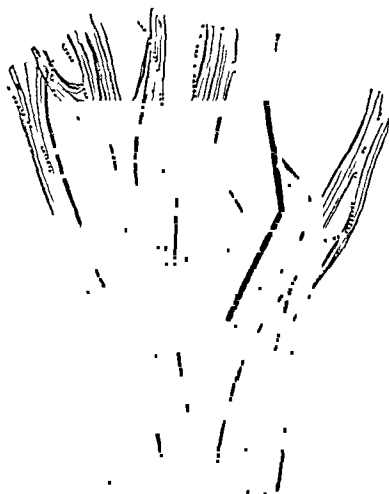ossific deposit.   A thin slice is then sawn off the radius

Fig. 76.—EXCISION OF THE WRIST.   (LISTER'S INCISION.)

parallel with the articular surface.   For this it is scarcely
necessary to disturb the tendons in their grooves on the
back, and thus the extensor secundi internodii may never
appear at all.

   " This may seem a refinement, but the freedom with
which the thumb and fingers can be extended, even within
a day or two of the operation, when this point is attended
to, shows that it is important.   The articular facet on the
ulnar side of the bone is then clipped away with forceps
applied longitudinally.

   " If the bones prove to be deeply carious, the pliers or

gouge may be used with the greatest freedom.   The meta-
carpal bones are next dealt with on the same principle, each
being closely investigated—the second and third being most
readily reached from the radial, the fourth and fifth from
the ulnar side.   If they seem sound, the articular surfaces
only are clipped off, the lateral facets being removed by
longitudinal application of the pliers.

" The trapezium is next seized with forceps and dissected
out, without cutting the tendon of the flexor carpi radialis,
which is firmly bound down in the groove on the palmar
aspect, the knife being also kept close to the bone to avoid
the radial.   The thumb being then pushed up by an assist-
ant, the articular end of the metacarpal bone is removed.
Though this articulates by a separate joint, it may be
effected, and the symmetry of the hand is promoted by
reducing it to the same level as the other metacarpals.

" Lastly, the articular surface of the pisiform is clipped
off, the rest being left, if sound, as it gives insertion to the
flexor carpi ulnaris and attachment to the anterior annular
ligament."

Comment.—The ulnar incision described above is not
absolutely necessary, and the amount of bone removed
must entirely depend upon the extent of disease.   Thus it
may be possible to spare most of the second row of carpal
bones with the pisiform and the bases of the metatarsus.
The less bone that is removed, so long as all the disease is
eradicated, the better will be the functional result.

CHAPTER VII.

EXCISION OF THE ELBOW.

THIS operation consists in the removal of the lower end of the humerus and the upper extremities of the radius and ulna.

Excision through a Posterior Median Incision.—The patient lies upon the back, with the body close to the edge of the table. The surgeon stands on the side that is to be operated upon. An assistant is placed on the opposite side of the table—*i.e.* upon the patient's sound side—and holds the limb. The upper arm should be vertical, or at right angles to the surface of the couch; the elbow should be a little flexed, and the forearm be carried across the patient's chest, so that the elbow projects prominently outwards. In dealing with the right joint the operator should stand by the patient's loins, and in dealing with the left, well to the outer side of the trunk. A second assistant, standing on the opposite side, can help to steady the limb by grasping the arm and forearm as he leans over the body; and a third helper, placed to the surgeon's left, should be prepared to assist in retracting the divided parts.

In this attitude it will be understood that the ulna and olecranon will be uppermost.

Narrow-bladed rectangular ˙retractors made of the stoutest steel are requisite.

(*a*) *The Incision.*—The skin incision is about four inches in length, is in the long axis of the forearm, and is so placed as to cross the centre of the olecranon fossa of the humerus, and to cross the centre of the olecranon process, and then follow the crest or posterior border of the ulna (Fig. 77, B).

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The centre of the incision should correspond to the tip
or summit of the olecranon, so that two inches of the cut
will be over the humerus and two inches over the olecranon
and ulna. The stout short-bladed excision knife may be
carried at once down to the bones, cutting on to the
olecranon, bisecting the triceps tendon, opening the
articulation through the posterior
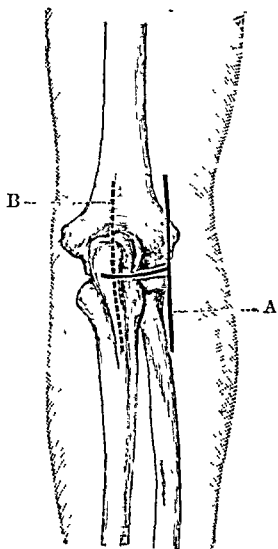ligament, and reaching the back
of the humerus.

Fig. 77.—EXCISION OF THE
ELBOW.
A, Roux's incision; B, Me-
dian vertical incision.

As the cut will be made from
"above downwards," it will be
seen that in the position occupied
by the limb the knife will cut first
upon the ulna, which is uppermost,
and then upon the humerus.

(*b*) *Clearing of the Olecranon
and the Condyles of the Humerus.*
—In clearing the bones for ex-
cision, the following rules should
be observed :—(1) The surgeon
should keep the knife well down
upon the bone, and his incisions
should be short and made with
force, and the edge of the blade
be kept turned towards the bones.
(2) The periosteum should be
separated to as great an extent
as is possible, and all ligamentous
connections should be spared. The
operator should aim at leaving the bones absolutely bare.
(3) The rugine and the elevator should be freely used, while
the knife is employed sparingly. The left thumb-nail must
be used with vigour to retract the tissues as soon as they
are separated, and the surgeon may expect that the thumb
of his left hand will remind him of the operation for many
days after. Good retractors must also be employed at
every step. The main feature of the operation is the
efficient peeling of the olecranon and the irregularly-shaped
humerus.

The inner part of the wound is first dealt with.

The inner half of the triceps tendon is peeled from the olecranon with as much periosteum as possible. The hollow between the olecranon and the internal condyle is now cleared until that process of bone is reached and is left bare and projecting.

If the operator keep close to the bones, and observe the three rules just laid down, there is no reasonable danger of wounding the ulnar nerve. The internal lateral ligament is stripped off from both humerus and ulna, and the periosteum is so separated as to carry with it the origin of the flexor muscles.

The surgeon now turns to the outer part of the incision, separating the tissues on that side until the outer epicondyle is reached and laid bare. In this stage of the operation the outer half of the triceps tendon will be separated and drawn aside without severing its connection with the deep fascia of the forearm, the anconeus will be raised from the ulna, the external lateral ligament and the origin of the mass of extensor muscles will be separated from the humerus, and the supinator brevis will be turned · well aside. Here again strong retractors are of great service. It is during this part of the procedure that damage may be done to the posterior interosseous nerve.

On both sides of the humerus the muscular origins should not be stripped off the bone higher than is required to clear the latter for the saw. It is hardly ever necessary to divide the bone much above the widest part—_i.e._ the level of the epicondyles.

The bones of the joint are now free of one another except upon their anterior aspect.

(c) _Sawing off the End of the Humerus._—The elbow should now be fully flexed, and without much difficulty the lower end of the humerus can be made to project into the wound. The patient's hand should then be placed in the prone position upon the operating table. In this attitude it can be firmly held, the lower ends of the radius and ulna being fixed rigidly upon the table. The assistant who grasps the upper arm should project the lower end of the

humerus upwards.   The portion of bone is now cleared of
its few attachments in front, and is bared as high up as is
necessary.

The surgeon then grasps the bone with lion forceps held
in the left hand and maintained vertically, as if he would
draw the bone directly upwards.

A narrow saw with a movable back is applied horizon-
tally to the lower extremity of the bone so fixed, and the
excision of the humerus is completed.

The saw-line generally crosses the bone at right angles to
its long axis, and just below the tips of the condyles.

In using the saw a metal retractor or spatula should be
employed to hold back and retract the soft parts.

(*d*) *Sawing off the Ends of the Radius and Ulna.*—
While the limb is in the same position the assistant who is
fixing the forearm relaxes his hold, and forcing the bones of
that part of the limb upwards, makes them in turn pro-
trude prominently into the wound.   The ulna is grasped with
the lion forceps, which are again held vertically, as if to
draw the bone directly upwards; and the metal spatula
having been applied, the saw is applied horizontally to the
base of the process, a slice of the upper end of the radius
being removed at the same time.

The wound is washed out, is adjusted with sutures, and
a drainage-tube is inserted.

Other Forms of the Operation.—The incision
most usually employed when the operation was first intro-
duced was the H-*incision of Moreau.*

Subsequent experience has condemned every form of
transverse incision in this operation.

Ollier's Operation by the Bayonet Incision.—The upper
part of this incision is vertical, is opposite the interval
between the triceps and the supinator longus, is commenced
2¼ inches above the joint-line, and runs down to the tip of
the outer condyle.

It is then directed obliquely downwards and inwards to
the base of the olecranon, and is finally made to follow the
posterior border of the ulna for 1½ to 2 inches.

A vertical incision about one inch in length is made

over the internal condyle. Through this small lateral incision the point of the condyle is bared and the attachment of the internal ligament separated.

Turning to the main wound, and using the rugine rather than the knife, the operator decorticates the external condyle, separating the external lateral ligament, exposes the head of the radius, detaches the triceps tendon together with the periosteum, denudes the olecranon and the margins of the sigmoid cavity, and detaches the insertion of the brachialis anticus.

The bones of the forearm are now luxated forwards, and are divided with a fine saw.

The inner segment of the humerus is in the next place freed of all its attachments, and, the bone being now bare, the saw is applied and the required section made.

After-treatment.—After the operation the limb must be placed upon a suitable splint, and the bones so adjusted that the greater diameters of the bony surfaces correspond and do not cross. The hand should be in the mid-position between pronation and supination, and the elbow be very slightly bent—so slightly that the forearm will be nearer to the extended posture than to the position it occupies when at right angles to the arm. The precise angle recommended by most surgeons is an angle of 135°.

CHAPTER VIII.

Excision of the Shoulder.

THE operation known by this name consists really of an excision of the upper end of the humerus. The shoulder-joint is not excised—or, in other words, that portion of the scapula which supports the glenoid fossa is not sawn away with the articular segment of the humerus. Portions of bone may be gouged from the glenoid fossa, but more than that is seldom done. The operation is comparatively rarely performed, and the conditions under which it is carried out are the same as lead to excisions of other joints. In a few instances the upper end of the humerus has been removed for a new growth.

To the greater tuberosity are attached the supraspinatus, infraspinatus, and teres minor; to the lesser process the subscapularis.

1. **The Operation by an Anterior Incision.**—The method here described is of the "open method" order. The subperiosteal operation is dealt with in the section which follows.

The patient lies upon the back, close to the edge of the table, with the shoulders well raised.

The elbow is flexed, and is carried a little from the side. The assistant who holds the limb sits or stands by the patient's loins. The surgeon takes up a position to the outer side of the shoulder and faces the subject. A second assistant stands behind the shoulder, facing the operator. The bony points about the joint should be defined.

(a) *The Incision.*—The incision, which is three and a half to four inches in length, commences at the outer side of the tip of the coracoid process, and is carried downwards

and a little outwards to follow the inclination of the anterior margin of the deltoid muscle (Fig. 78, A).

The knife is carried straight down to the joint, the coraco-acromial arch is exposed, and the capsule of the joint laid bare in the line of the incision. The biceps tendon is next sought for, and the capsular ligament is opened vertically just to the outer side of the tendon. It is most conveniently incised from below upwards.

(b) *Separation of the Outer Margin of the Wound.*—The operator now proceeds to clear the tissues from the bone upon the outer side of the wound. In the case of the right limb this will be the left margin of the wound, and in the case of the left limb the right margin.

The parts are well retracted with the left thumb, aided when required by retractors. The surgeon uses a blunt-pointed knife, and separates the soft parts from the upper end of the humerus by cutting on to the bone.

Fig. 78.—EXCISION OF THE SHOULDER.

A, Incisions of Baudens, Hueter, and Ollier; B, Vertical incision of Langenbeck and others; C, Morel's incision.

The instrument should be kept as close to the bone as possible. As the separation proceeds, the assistant rotates the humerus inwards, while at the same time he depresses the elbow and forces the head of the bone forwards.

The surgeon clears the capsule from the outer part of the bone, and on reaching the external tuberosity severs the insertions of the supraspinatus, infraspinatus, and small teres muscles.

The second assistant aids in retracting the soft parts.

(*c*) *Separation of the Inner Margin of the Wound.*— The limb is restored to the position it originally occupied, and the surgeon proceeds to clear the bone upon its inner aspect in the manner just described. The humerus is rotated outwards as he proceeds ; and when the lesser tuberosity is reached, the subscapularis insertion is divided, and the attachment of the capsule beyond it.

In this stage care must be taken of the biceps tendon, which should be drawn aside.

(*d*) *Clearing of the Neck of the Bone.*—The biceps tendon is displaced inwards. The elbow is flexed, and the arm is held vertically (*i.e.* at right angles to the table), and is thrust upwards so that the head of the bone is made to project through the wound. The posterior part of the neck of the bone is cleared, and the parts are prepared for the passage of the saw.

(*e*) *Excision of the Head of the Humerus.*—The head of the bone is seized with lion forceps held in the surgeon's left hand, and the bone is sawn through with either a small Butcher's saw or a thin saw with a movable back. The saw-cut should incline from without very slightly downwards and inwards, so that no sharp end may be left which might press upon the axillary vessels or nerves.

In sawing the left humerus the surgeon stands facing the patient ; in dealing with the right he will find it more convenient to stand behind the shoulder (by the patient's head). While the saw is being used, the soft parts must be protected by metal spatulæ.

(*f*) The glenoid cavity is examined, and its diseased surface gouged away. The skin incision is closed with sutures, and the limb placed in position.

It should be noted that, so long as all diseased bone and synovial membrane is removed, the insertions of the rotator muscles should be interfered with as little as possible. It is unnecessary to force the humeral head out into the wound, as it may be divided with a chisel as it lies in position. The synovial pouches in connection with the

subscapularis and biceps muscles should be carefully dissected out.

Comment.—This procedure can claim to be the best and the most generally adopted method of excising the shoulder.

Langenbeck's incision is placed more to the outer side, and has for its starting-point the acromio-clavicular joint (Fig. 78, B).

2. **The Subperiosteal Operation.**—The patient is placed in the same position as in the last operation. The arm lies by the side. The same incision is made. The capsule is exposed and the biceps tendon discovered.

The capsule is incised vertically to the outer side of the biceps tendon, and the incision is carried downwards through the periosteum on the neck of the bone as far as the intended saw-cut. The knife is now laid aside for the rugine and elevator. Commencing at the outer segment of the wound, the surgeon separates all the soft parts from the bone, detaching the periosteum, the capsular ligament, and the muscular insertions in one continuous and unbroken layer. The rugine is worked upwards and downwards. The arm is rotated inwards gradually, and is at the same time abducted and the head of the bone pushed upwards and forwards. The greater tuberosity is reached and cleared, and the bone freed as far as possible beyond it. In clearing the outer part of the humerus, the surgeon should stand facing the patient while dealing with the right limb, and behind the shoulder—*i.e.* close to the head—while treating the left limb.

In the process the thumb and suitable steel retractors must be vigorously employed to draw back the separated tissues.

The next step consists of clearing the lesser tuberosity and the inner part of the neck of the bone. Like measures are adopted. As the surgeon progresses, the limb is rotated outwards, the arm is abducted, and the head of the humerus is thrust upwards and forwards.

In this part of the operation the surgeon stands facing the patient when excising the left bone, and behind the shoulder when operating upon the right side.

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The head of the bone is now thrust out of the wound, and the neck is cleared of any remaining ligamentous or periosteal attachments.

The excision of the head is carried out in the manner already described.

Comment.—The deltoid flap which was once so much made use of is shown in Fig. 78, c. This form of operation has the advantages of being easy of performance and of well exposing the parts of the joint. It has the overwhelming disadvantage of destroying the function of the deltoid muscle.

CHAPTER IX.

Excisions of the Toes, Metatarsus, and Tarsus.

The general as well as the detailed observations that apply to the fingers and metacarpus apply also to the corresponding parts of the foot.

1. **The Astragalus.**—The patient lies upon the back, and the foot is so placed as to extend beyond the end of
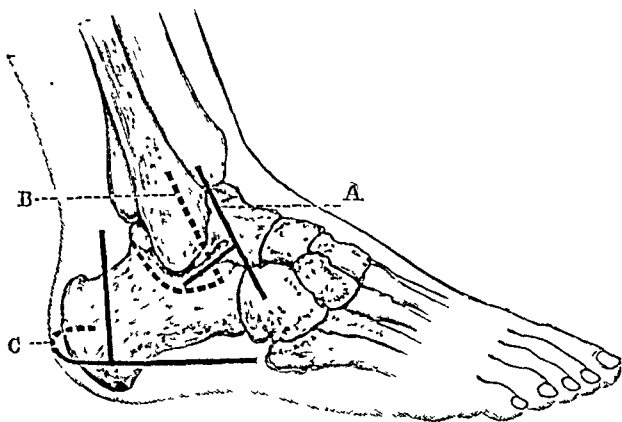
Fig. 79.—A, Excision of astragalus (outer incision); B, Excision of ankle (outer incision); C, Excision of os calcis.

the table. It must be held by an assistant, who can manipulate it as directed.

Two incisions, external and internal, are made. The outer incision is about two and a half inches in length, runs parallel with and just posterior to the tendon of the peroneus tertius, and commences a line or so above the level of the articular margin of the tibia (Fig. 79, A).

A second and much shorter cut starts from the centre of the principal incision, is placed at right angles to it, and ends immediately below the tip of the outer malleolus. The two slight flaps thus defined are turned aside, and the bone exposed in the interval between the peroneus tertius and peroneus brevis tendons.

The foot is well extended and inverted, and the ligaments which connect the bone with the fibula, tibia, scaphoid, and os calcis are divided so far as they can be reached from the outer side.   Retractors are used to protect the tendons, etc.

The inner incision is about two inches in length, and, starting from just below the tip of the inner malleolus, is carried forwards and upwards just in front of the anterior margin of that bone.   It will be curved, therefore, with the concavity backwards (Fig. 80, A).

The remaining ligaments that hold the astragalus are now divided from the inner side.

The surgeon turns finally to the outer wound, and while the foot is inverted and extended, grasps the astragalus with lion forceps in a vertical direction, and as Farabeuf expresses it, " whips it out like a molar."

The wound will need to be drained, and the limb to be firmly secured upon a splint or in plaster of Paris, with the foot at right angles to the leg.

2. **The Os Calcis.**—Among the many methods devised for the excision of this bone, the procedure described by Farabeuf appears to be upon the whole the best.   The incision he recommends is a combination of the horse-shoe incision employed by Erichsen and the simpler skin-cut made use of by Ollier.

The operation should be performed as far as is possible by the subperiosteal method.

The patient lies upon the sound side, the leg is supported upon a sand pillow, and the foot, turned well upon its inner border, is free.

The incision, commencing at the base of the fifth metatarsal bone, is carried horizontally backwards just above the margin of the sole, and, passing round the hinder aspect

of the heel, ends about one inch and a quarter to the inner side of the median line (Fig. 79, c).

This cut is met by a vertical incision two inches in length, which is parallel to and a little in front of the tendo Achillis. The wound is deepened, and two small flaps are formed. Great care must be taken of the peronei tendons, to which the vertical incision is posterior. The bone is exposed behind the peronei tendons, and the periosteum is incised vertically. With a rugine the periosteum and the associated ligaments are separated from the bone. The outer surface is cleared first, then the posterior surface. The attachment of the tendo Achillis is severed. The foot being placed in the position of talipes varus, the posterior aspect is bared of periosteum as far as it is possible to reach. The anterior portion of the bone is cleared, and the ligaments separated with the periosteum. The same is done with the plantar surface. A certain part of the inner surface can be reached from the posterior aspect.

With care and patience and the use of good retractors the greater part of the bone can be bared through this outer incision, and from this side also the interosseous ligament can be reached and divided.

When the os calcis is freed as far as possible, the head or anterior part must be grasped with lion forceps and the bone dragged outwards with a repeated rotatory movement, the periosteum and ligaments upon the inner surface being separated with the rugine as soon as each part of the as yet untouched district is reached.

CHAPTER X.

Operation.—The various methods in vogue for per-forming this operation are for the most part modifications of the original procedure of Moreau. Indeed, no very conspicuous deviations from the initial operation have been proposed or carried out. Of the modern forms of Moreau's operation, that by Langenbeck would appear to be one of the best. It may be carried out as follows, if the sub-periosteal method be attempted :

The patient lies upon the back, with the foot and leg supported upon a firm sand pillow. Two vertical lateral incisions are made. The leg and foot should be rendered bloodless by the application of Esmarch's tourniquet, other-wise it will be impossible to dissect out thoroughly all the diseased tissues in a case of tuberculous ankle.

1. *The Outer Incision.*—The foot being turned over upon its inner side, a vertical incision some three inches in length is made along the anterior part of the fibula to a point a little below the tip of the malleolus. Thence it is made to curve around the malleolus, and ascend for about one inch along its posterior border (Fig. 79, B).

2. *The Removal of the External Malleolus.*—The fibula is exposed, and its periosteum divided in the long axis of the bone. The membrane is then separated from the bone by the rugine in an anterior and a posterior direction.

The ligaments attached to the malleolus are separated as encountered. The external lateral ligament is divided vertically, so that its anterior segment will go with the anterior layer of separated periosteum, and its hinder segment with the posterior layer.

With the curved rugine the greater part of the circum-

ference of the shaft of the bone can be bared about the saw-line.

The fibula is then divided with either a chisel or a saw about one inch above its extremity.   The divided end is seized with lion forceps, or is drawn outwards with a hook, while its deeper connections are separated with the rugine, aided by the knife.

This part of the operation is very tedious.

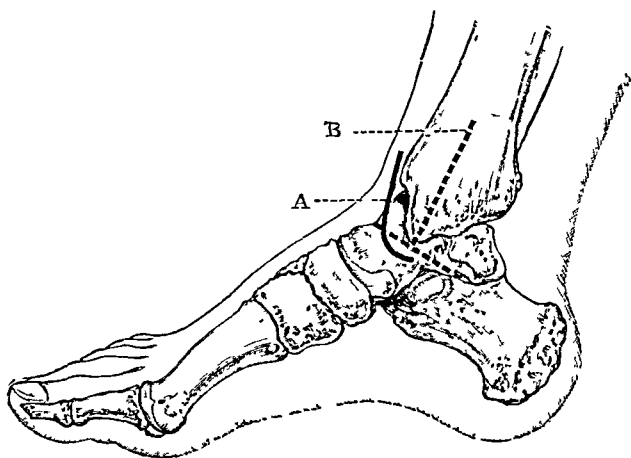The lower end of the fibula is thus removed.

Fig. 80.—A, Excision of astragalus (inner incision) ; B, Excision of ankle (inner incision).

3. *The Clearing of the Tibia.*—As much of the anterior and posterior surfaces of the tibia as can be reached through the outer cut are bared of periosteum by means of the rugine, the anterior and posterior ligaments of the ankle being elevated with the periosteal layers.   In this part of the operation care must be taken not to open the sheaths of the tendons.

4. *The Inner Incision.*—The foot is turned upon its outer side, and an incision about three inches long is made along the inner surface of the tibia and in the long axis of the

bone. The cut ends at the tip of the inner malleolus. A curved or transverse incision (Fig. 80, B) may be made to meet the lower end of the wound at right angles.

5. *The Removal of the Articular Surface of the Tibia.*— The periosteum of the tibia is incised vertically, and that membrane is peeled from the bone so that it may be continuous with the periosteo-capsular layers already separated upon the outer side. The internal lateral ligament is divided vertically in the manner already described with regard to the outer ligament.

As soon as the tibia is sufficiently free, the malleolar end of it is made to project a little through the wound, and while the soft parts are well protected with retractors, the bone is divided horizontally with a keyhole saw. This section removes the internal malleolus and the diseased articular surface of the tibia. A thin layer of bone should be removed with the saw, and, if necessary, any patches of caries should be further gouged out. The fragment is grasped with lion forceps and removed.

6. *The Sawing of the Astragalus.*—The surgeon finally turns once more to the outer incision, and through that wound removes with the saw as much of the upper part of the astragalus as is necessary. The section should be horizontal. If found absolutely necessary, the whole of the astragalus may be removed through the external incision. The best result will, however, be obtained if firm bony ankylosis occurs between the cut surface of the tibia and astragalus, and hence the less that is removed of that bone the better, so long as all tuberculous foci are dealt with.

7. *The Excision of the Tuberculous Synovial Membrane, etc.*—This should be carefully and systematically done, the surgeon paying special attention to the joint capsule behind the extensor tendons, the prolongation upwards of the cavity between the tibia and fibula, and to diseased pouches which are often present on either side of the joint. If these latter cannot be dissected out, they must be thoroughly scraped with Volkmann's scoops.

CHAPTER XI.

EXCISION OF THE KNEE.

THE upper limit of the femoral epiphysis will be repre-
sented by a horizontal line drawn across the bone at the
level of the tubercle for the adductor magnus.   If the
whole of the trochlear surface be removed in the incision,
the whole of the epiphysis will have been taken away.
A single nucleus appears in this epiphysis shortly before
birth, and joins the shaft about the twentieth year.   The
epiphyseal line is intracapsular.

The limits of the tibial epiphysis are represented behind
and at the sides by a horizontal line that just marks off the
tuberosities.   It includes, therefore, the depression for the
insertion of the semimembranosus, and also the facet for the
fibula.

In front the epiphyseal line slopes downwards on either
side to a point on the upper end of the shin, so as to enclose
the whole of the tubercle of the tibia.

The centre joins the main bone at the twenty-first or
twenty-second year.   The epiphyseal line is extra-articular.
Farabeuf estimates that in a child of about eight years of
age it is impossible to remove more than 1 cm. of the
tibia, or $1\frac{1}{2}$ cm. ($\frac{7}{12}$ of an inch) of the femur, without
approaching dangerously to the epiphyseal lines.

After puberty (e.g. in a youth of seventeen years) it is
possible to remove $1\frac{1}{2}$ cm. of the tibia, and $2\frac{1}{2}$ cm. (1 inch)
of the femur, without compromising the epiphyseal lines.

The popliteal artery is so placed that it is in greater
risk of being wounded when the tibia is sawn than when
the lower part of the femur is being removed.

**Operation   by   a   Curved   Transverse
Anterior Incision.**—Of the many methods which have

been described and adopted, this appears to have substantial claims to be regarded as the most suitable.

Position.—The patient lies upon the back, with the limb close to the margin of the table. The lower part of the leg should project a little beyond the table, so that when the knee is bent at a right angle the foot may be able to rest, flat upon the sole, upon the end of the table.

The surgeon stands upon the side to be operated on.

Some surgeons prefer to stand upon the left side of the limb in the case of either extremity, a position which is certainly more convenient for sawing.

One assistant places himself opposite to the surgeon, and steadies the limb by the thigh. Another assistant near the foot of the table holds the leg, and manipulates it as required. A third assistant by the surgeon's side attends to the sponging, etc.

At the commencement of the operation the limb is held with the knee a little flexed. Later, the joint is bent at a right angle.

(1) *The Skin Incision.*—A curved incision, convex downwards, is made across the front of the knee below the patella.

The incision commences and terminates at the posterior margin of one of the femoral condyles, whilst its lowest point in front corresponds with the insertion of the patellar ligament.

During the making of this wound the knee-joint is held a little flexed, and the skin and subcutaneous tissues are alone divided at the first sweep of the knife.

(2) *Dividing of the Ligaments.*—The knee is now flexed a little more, and with another sweep of the knife the anterior part of the capsule and the patellar ligament are cut through, and the joint opened below the knee-cap.

The patella, with its attached aponeurosis, is turned upwards, the joint is still more flexed, and the surgeon proceeds to divide in order the lateral and the two crucial ligaments.

(3) *Sawing of the Femur.*—The joint is now bent at a

right angle, and the limb held firmly in that position, with the sole of the foot planted upon the table.

The femur is cleared with the knife at the future saw-line.

The bone is sawn from before backwards, and with regard to the plane of the section these two points must be observed :—

The plane of the saw-cut in the antero-posterior direction must be at right angles to the long axis of the shaft of the femur, and in the transverse direction it must be parallel to the plane of the free surface of the condyles.

During the sawing process the condyles may be grasped and steadied with lion forceps, although, if the limb be firmly held, this is not necessary. The femur rests upon the tibia. The tissues of the ham must be protected by means of an ivory spatula held behind the femoral condyles, or by a broad elastic or thin metal band.

(4) *Sawing of the Tibia.*—The upper end of the tibia is now held forwards, the foot is still pressed firmly against the table, the shaft of the bone is maintained in the vertical position, and in consequence the articular surface will be quite horizontal. The bone is cleared with the knife for the passage of the saw, and a thin slice is removed by sawing from before backwards, the saw being kept precisely parallel to the articular surface, and therefore at right angles to the shaft. (Fig. 81.) The popliteal tissues must be protected in the manner already described ; and if the movements of the saw be slow and deliberate, there is no danger of wounding the structures of the ham.

The two bony surfaces should now be parallel, and should fit accurately when brought together.

(5) *Treatment of the Patella and Synovial Membrane.*— The most tedious part of the operation remains. The patella must be dealt with according to the practice of the individual surgeon. It may be removed, whether healthy or diseased, by dissecting it out, with the least possible disturbance of the surrounding tissues ; or if entirely sound, it may be left. Or it may be steadied in a vertical position while its articular segment is removed with the saw in the

form of a thin layer; or its tissue may be so scraped and cut away that nothing remains but the anterior layer of compact bone.

With the knife and scissors, aided by the sharp spoon, the surgeon now proceeds to remove all the diseased synovial membrane which may remain. The pouch beneath the quadriceps tendon is opened up, and is carefully cleared out by means of the sharp spoon.

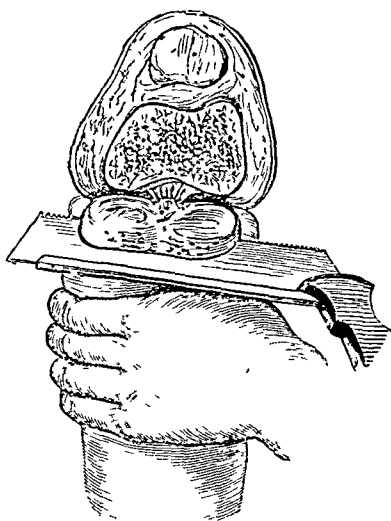Any existing sinuses are opened up and scraped, and by

Fig. 81.—EXCISION OF THE KNEE: THE SAWING OF THE TIBIA.

one means or another a careful and determined attempt is made to rid the operation area of every trace of diseased tissue. The part is now well flushed with sterilised warm water, and carefully dried.

Nothing remains but to close the wound with sutures—silkworm gut being the best for the purpose—and to adjust the limb upon the splint which has been prepared for it.

The drainage-tubes will be inserted before the limb is adjusted to the apparatus.

No blood-vessels of any importance are divided. The arteries actually severed will be branches of the articular arteries, of the anastomotica magna, and of the anterior tibial recurrent. Continued pressure with a dry sponge will be sufficient to check such bleeding as is usually met with.

In the majority of instances it is possible to leave the posterior ligament undisturbed, in which case a substantial barrier remains that will prevent the spread of suppuration into the popliteal space should pus be produced.

In any case, care should be taken to spare this ligament, and to separate its attachments from the bones rather than to cut it.

The internal limit of the incision should not be carried backwards beyond the point indicated, in case the internal saphenous vein and nerve be wounded.

The utmost care must be taken to respect the epiphysis in young subjects. If damaged, it will lead to a shortened, deformed, and possibly useless limb.

The femur and the tibia should be sawn from before backwards.

With regard to the fixing of the bones with metallic sutures or pegs, it must be observed that such a measure effects its object but feebly, that primary healing is apt to be hindered, that the subsequent removal of the wires or pegs may be difficult, and that the presence of these foreign bodies may excite some mischief in the bones.

If a really suitable strong and well-adjusted apparatus be used to fix the limb, the employment of the means just named becomes quite unnecessary.

CHAPTER XII.

EXCISION OF THE HIP.

THIS operation implies the removal merely of the upper end of the femur, and the scraping away of any diseased tissue which may occupy the acetabulum   As in the case of the shoulder-joint, so here also the excision does not involve the whole joint and the entire articulating surfaces.

Barker's Operation by Anterior Incision.— The patient lies supine, with both thighs fully extended. The surgeon stands in every case on the right side of the patient; one assistant, facing him, holds the affected thigh, another stands beside and to the left of the operator.

The most precise and rigorous aseptic measures are carried out.

The incision commences on the front of the thigh, half an inch below the anterior spinous process of the ilium, and runs downwards and a little inwards for three inches.   As the knife sinks into the limb it passes between the tensor vaginæ' femoris and glutei muscles on the outside, and the sartorius and rectus on the inside, until it reaches the neck of the femur.   This incision does not divide .any muscle fibres, nor vessels or nerves of the slightest importance.   It is unnecessary to carry the deeper part of the incision to the full extent of the external wound.   If an abscess is opened up before the joint is reached, its contents are thoroughly flushed out with sterilised hot water, at a temperature of between 105° and 110°, before anything further is done.   For this purpose a large three-gallon can is used, with three taps below, to each of which six or eight feet of india-rubber tubing is attached   This can is placed some feet above the operating-table, so as to have a considerable pressure of water.   Each of the rubber tubes

terminates in one of Barker's flushing-gouges. These instruments consist of a gouge with a canal running through the handle, so that a stream of water may be directed into the hollow of the gouge. The abscess having been cleared out by means of the rush of hot water, aided by these flushing-gouges, the neck of the femur is sawn across with a narrow saw in the direction of the external wound. The diseased head can then be lifted out by means of the flushing-scoop or a sequestrum forceps, through which the hot stream is rushing into the joint. By the time the head of the bone has been got out, the whole cavity is comparatively clean.

Now begins the search for further disease. This can usually be estimated by the left forefinger, with which the acetabulum is first examined, and then all the other parts of the joint-cavity. Wherever diseased material is felt, it is cut away by the flushing-gouge or scoop, the hot water carrying away the *débris* as fast as it is produced, and with it all blood, while at the same time it arrests bleeding from the fresh-cut surfaces. When every part of the

Fig. 82.—EXCISION OF THE HIP.

field of operation has been gouged and scraped clean of all tuberculous material, and the water runs away clear, the cavity is dried out with sterilised sponges, one or two of which are left in it until all the stitches are placed in position. These should dip deeply and be placed close together. Just before they are tied, the sponges are removed, and with them the last traces of moisture. A little iodoform is now dusted over the surface of the
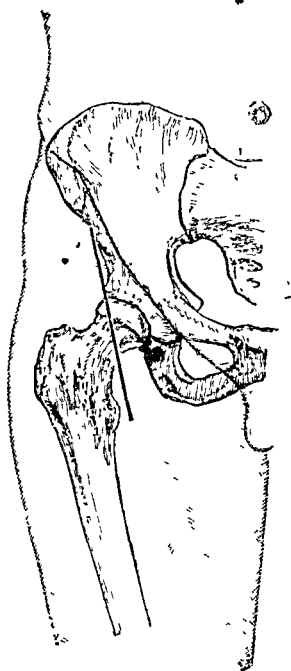
incision—in which there is no drainage-tube in most cases
—and the whole joint is covered with aseptic gauze so
adjusted that evenly-graduated pressure is brought to bear
upon every aspect of the field of operation, while the limb
is held well abducted. If the wool be now firmly com-
pressed with a spica bandage, the walls of the whole clean-
scraped cavity are brought into contact, and the remainder
of the neck of the femur is thrust into the acetabulum and
secured there.

Now when all this has been done, although there
remains potentially a cavity, there is actually nothing of
the kind, for all the surfaces have been brought into
apposition. And then, assuming that perfect asepsis has
been observed, all these surfaces ought to unite with a
minimum of exudation. After the operation the patient is
at once placed upon a Thomas's double splint.

CHAPTER XIII

Arthrectomy, or Erasion of a Joint.

This operation, although it is distinct from excision, may most conveniently be considered here.

It consists in fully exposing the interior of the joint, and in removing the whole of the diseased synovial membrane and ligamentous tissue, together with such patches of cartilage or bone as may be the seat of quite limited disease.

This removal is accomplished by means of the scalpel, the scissors, the sharp spoon, the gouge, and, if need be, the actual cautery. The measure aims at removing *all* the diseased tissue, and diseased tissue *only.*

Instruments required.—Excision knife; scalpels; scissors, both straight and curved on the flat; sharp spoons of various sizes and shapes; gouges; toothed forceps; dissecting and artery forceps; pressure forceps; probe; retractors.

The Operation (*as applied to the knee-joint*).—An Esmarch's band is not required, nor is any form of tourniquet needed.

The patient lies upon the back, with the knee a little flexed and the sole of the foot resting flat upon the table.

The surgeon stands to the outer side of the limb, or he may find it convenient to place himself upon the right side in the case of either limb. An assistant placed at the end of the table, and another opposite to the surgeon, hold the limb securely. A third helper by the surgeon's side attends to the sponging, etc.

A curved transverse incision is made across the front of the knee-joint, as in performing excision (page 242). The incision may be commenced at the posterior part of one

condyle of the femur, be carried across the front of the limb over the middle of the patellar ligament, and end at the posterior part of the other condyle.

The patellar ligament is divided, the joint fully opened, and the skin flap with the patella turned up upon the thigh.

The knee is now flexed at a right angle, and the interior of the joint well exposed.

The surgeon then proceeds to remove all the diseased synovial membrane, and such of the extrasynovial tissue as is also involved. The latter would include all softened ligamentous tissue. As much as possible should be removed in a continuous layer by means of the scalpel and forceps, or the scissors and forceps. The semilunar cartilages are removed, and probably both lateral ligaments.

The crucial ligaments should be spared whenever possible. They must be stripped, however, of every trace of diseased membrane, must be most carefully inspected, and subjected to a vigorous scraping over all suspicious parts.

The articular surface of the posterior ligament must be exposed, and also freed of all degenerate and pulpy tissue.

This ligament should not be divided, nor should any opening, if possible, be made into the popliteal space.

When the interarticular district has been completed, and the work of the scalpel or scissors followed up by the sharp spoon, until no trace of disease has been left behind, the surgeon turns to the anterior flap.

All the synovial membrane which covers this flap should be dissected off, the subcrural bursa must be fully opened up, and its lining membrane treated in the same way. Every nook and cranny must be patiently explored, and every fragment of tuberculous tissue removed. The complete removal of every scrap of diseased tissue from the subcrural bursa is very important.

Here again also the erasion must be completed with the sharp spoon, and every neglected point and corner subjected to a careful and complete scraping.

Finally, the cartilages and bones must be well examined. Patches of softened or eroded cartilage may be sliced off, and points of caries in the bones freely removed with a gouge.

The bleeding is arrested by the pressure of a sponge, which is maintained as long as possible, and by means of pressure forceps. Ligatures are but seldom required.

The articulation is then well washed out with sterilised warm water, well sponged, and dried.

The limb is placed upon the splint prepared for it, and the patellar ligament having been united by many points of chromicised catgut, the wound is closed with silkworm gut.

Drainage-tubes should be avoided whenever possible, and in a large percentage of the cases they can be dispensed with, provided that the margins of the wound are not too closely approximated.

If drains be considered necessary, one should be inserted into the posterior angle of the wound on each side.

CHAPTER XIV.

Excision of the Upper Jaw.

THIS operation is considered to refer usually to the removal of the superior maxillary bone of one side, but to include also the rarer operation in which both bones—and therefore the whole of the upper jaw—are excised at one sitting.

The Operation by a Median Incision.—This procedure forms, without doubt, the best measure for excising the superior maxilla.

The patient lies upon the back, with the head and shoulders well raised. The face, if the patient be a male, should have been already shaved. The head is turned to the sound side.

Hewitt and Sheild (*Med.-Chir. Trans.*, 1896, page 18) advise the complete lateral position of the patient, with his head at the edge of the table and the face turned towards the floor. Blood drains away readily in this position without risk of its entering the trachea.

The surgeon stands on the patient's right-hand side in dealing with either side of the jaw. The chief assistant should take his place opposite to him. Another assistant may stand by the surgeon's side. The posterior nares are well plugged.

1. The incision is commenced at a point half an inch below the inner canthus, is carried down by the side of the nose—where the nose joins the face—follows the groove which limits the ala nasi, and, skirting the nostril, reaches the median line of the lip.

· While this cut is being made, an assistant may compress the facial artery.

When the lip is reached, the chief assistant grasps each extremity of the lip (at either angle of the mouth) between

the finger and thumb, so as to compress the coronary arteries. The incision is then carried through the median line of the upper lip into the mouth (Fig. 83, A).

The superior coronary arteries are at once seized and secured.

While the lip is being dealt with the upper part of the wound is being compressed by a sponge.

In this stage of the operation the following vessels are divided :—The angular artery and the large angular vein, the lateralis nasi artery, the superior coronary, the artery to the nasal septum, and some trifling branches of the infra-orbital.

2. A second incision is now carried along the lower margin of the orbit. At its commencement it starts from the point of the first incision, and ends over the malar bone (Fig. 83, A).

3. The cheek flap thus marked out is now rapidly raised from the bone, and should contain all the soft parts down to the maxilla.

Fig. 83.—EXCISION OF THE JAWS.

A, By a median incision; B, By Velpeau's method; C, Excision of the lower jaw.

No attempt should be made to save the periosteum. In dissecting up this flap the infra-orbital artery is divided. Care should be taken that no blood runs into the mouth, and an assistant should follow the flap with a sponge.

Throughout the operation sponge pressure is the main means of checking hæmorrhage.

4. The operator should now separate the nasal cartilages from the bones, and should then divide the nasal process. This may be done with a fine saw or a chisel. He should next proceed to divide the periosteum along the lower edge of the orbit. With the elevator the periosteum of the floor of the orbit is carefully raised, and in effecting this the origin of the inferior oblique muscle is separated.

With a fine chisel the orbital plate may be divided as far within the orbit as is necessary. The chisel-cut will commence at the point at which the nasal process of the maxilla has been divided, and will end at the spheno-maxillary fissure. If it be considered necessary to take away the whole of the orbital plate of the maxilla, then a chisel-cut can scarcely avail, and the bone must be wrenched away from its attachments in the final act of removal.

The last step of this stage of the operation is to divide the malar bone. This may be done with a chisel or a small saw. The malar bone is divided obliquely (from above downwards and outwards) at a point about the centre of the bone, and the saw or chisel is so applied that the section will extend into the spheno-maxillary fissure, the exact site of which should have been previously defined.

5. The palate part of the bone alone remains with its connections undisturbed. The mouth having been well opened, the central incisor tooth on the diseased side is removed, the muco-periosteal covering of the hard palate is divided in the median line, and a knife is drawn along the floor of the nose from before backwards and as near as possible to the septum. By means of a transverse incision made through the mouth the soft palate is loosely separated from the hard.

A keyhole saw is now introduced through the nose, and the bony palate divided as near to the median line as is possible. This step of the operation should be rapidly performed, as there is often much bleeding from the palatine arteries, which are necessarily divided.

6. The surgeon finally grasps the bone with lion forceps, holding the instrument with its blades opened vertically. One blade takes hold of the orbital plate, and the other of the alveolus. The maxilla is then wrenched from its few remaining attachments. These will in part concern the orbital plate, and in part the attachment existing between the maxilla and the pterygoid process. The separation of the bone from the last-named process may be aided by bone-cutting forceps bent at an angle and introduced behind the maxillary tuberosity.

Care must be taken at this stage that the soft palate is freed completely from its connections with the hard.

Without bringing much force to bear upon the forceps, the bone is finally removed.

7. Any bleeding from the depths of the cavity should now be checked so far as is possible.

It will usually be desirable to plug the cavity with gauze. Iodoform or cyanide gauze may be employed. The amount introduced must be noted, and the ends of the strips so placed that they can be readily reached from the mouth.

A silk thread may be attached to the end of each strip, and brought out of the mouth and fastened to the cheek.

The actual cautery may sometimes be used with good effect to check the hæmorrhage.

The skin wound is finally united very carefully with silkworm-gut sutures, especial care being taken to accurately adjust the red margin of the lip. No harelip pins are necessary in any ordinary case.

CHAPTER XV.

Excision of the Lower Jaw.

A LARGE number of the operations are partial, and only in a few instances is it necessary to remove the entire bone —*i.e.* both the right and left portions of the maxilla.

Instruments Required.—The same as for excision of the upper jaw, with the addition of a small saw with a movable back, or a small Butcher's saw, and a needle in a handle for securing the tongue if necessary.

Removal of One Half of the Lower Jaw.— The patient lies upon the back, with the head and shoulders raised, and with the trunk close to the edge of the table. The surgeon stands on the side to be operated upon. Some find it more convenient to stand on the patient's right in dealing with either side of the maxilla.

The head is turned to the sound side. The chief assistant takes his place opposite to the surgeon. A second helper stands by the operator's side.

In male subjects the chin will have been already shaved.

1. A vertical incision is made through the tissues of the chin, in the middle line, starting just below the lip, which is not divided. From the lower end of this another incision is carried along and just below the inferior border of the jaw for its entire length, and is then directed upwards along the posterior margin of the ascending ramus, to end opposite to the lobule of the ear (Fig. 83, *c*).

The incision is carried throughout down to the bone, except in one place—viz. where the knife crosses the facial artery. Here the wound is only skin deep.

After the incision has been made, the surgeon returns to the spot indicated, exposes the facial artery by dissection, secures it between two ligatures, and divides it.

With a periosteal elevator or rugine the muscles attached to the external surface of the maxilla are rapidly separated from the bone, and are turned up with the integuments in the form of a flap. The separation is commenced at the symphysis, and carried backwards. The buccinator and masseter are peeled off from the bone in this part of the operation. The mental and masseteric arteries, together with some smaller branches, are divided at this stage.

It is desirable that the operator should keep close to the bone.

The cavity of the mouth is now opened by dividing the buccal mucous membrane at its junction with the alveolus.

2. The surgeon now extracts one of the incisor teeth—the lateral incisor, as a rule—and with a keyhole saw divides the jaw vertically in the line of the gap. It is often more convenient to saw the bone nearly through, and then to complete the section with suitable bone-cutting forceps. More or less of the genio-hyoid, genio-hyo-glossus, and digastric muscles will be disturbed in clearing the inner surface of the bone.

3. The anterior extremity of the divided maxilla is now drawn outwards, and with a blunt-pointed knife kept close to the bone the surgeon divides the attachment of the mylo-hyoid muscle. The internal pterygoid muscle is reached, and may be conveniently separated from the bone by means of a periosteal elevator. The lower border of the maxilla is twisted outwards, in order that the whole of the attachment of the internal pterygoid muscle may be dealt with.

The inferior dental artery and nerve are exposed and divided. In this part of the operation care must be taken to avoid injury to the sublingual and submaxillary glands.

4. The anterior part of the jaw is now forcibly depressed, in order to bring the coronoid process into view in the posterior part of the wound.

The tendon of the temporal muscle is divided with scissors curved on the flat as each part of the fibres of insertion is successively reached.

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Some surgeons divide the coronoid process with a chisel
and mallet, and subsequently dissect out the fragment of
bone thus isolated.

The jaw is still further depressed, in order that the
condyle may be brought into view.

The external pterygoid muscle is reached, and is de-
tached with the elevator or divided with scissors. The
capsule of the joint is severed, the articulation is opened
and the condyle freed. Throughout this stage of the
excision the jaw should be merely depressed. It should not
be twisted. If it be much everted or rotated out, the
internal maxillary artery may be brought into contact
with the neck of the bone, and may be accidentally
divided or even torn.

It only remains now to cut the bone free of its few
surviving attachments, which are represented by the
internal lateral, stylo-maxillary, and pterygo-maxillary
ligaments, together with more or less fascia and the remain-
ing fibres of the outer pterygoid muscle.

All bleeding having been checked, the wound is united
with silkworm-gut sutures. The chin part of the incision
should be adjusted with especial care. A drainage-tube
may be introduced into the hinder part of the wound, and
retained there for twenty-four hours.

A dressing composed of a sponge dusted with iodoform,
and kept in place by a layer of wool and a supporting
bandage, will be found to be efficient.

Esmarch's Operation.—In this operation a wedge-
shaped piece of bone is removed from the horizontal
portion of the maxilla, with the intention of establishing a
false joint.

The *wedge* of bone to be removed must be taken
from the horizontal ramus of the jaw, anterior to the
masseter and in front of the contracted tissues. The base
of the wedge will be below, and in an ordinary case in an
adult should measure one inch and a quarter. The apex is
at the alveolar border, and should be about three-quarters
of an inch in width.

An incision some two inches in length is made along the

lower border of the jaw at the spot at which it is intended
to remove the wedge. The bone having been well exposed
and the periosteum divided, a wedge of bone is removed
with a keyhole saw, aided by the chisel and a periosteal
elevator. After all bleeding has been checked the wound
is closed by sutures.

Excision of the Condyle of the Jaw.—This
operation is identical with the so-called excision of the
temporo-maxillary articulation.

A vertical incision is made over the site of the joint and
condyle. It is placed anteriorly to the temporal artery,
starts at the lower margin of the zygoma, and ends below,
just short of the transverse facial artery. The temporal
artery may be considered to run about a finger's-breadth in
front of the tragus, while the transverse facial artery is a
little less than a finger's-breadth below the zygoma.

This incision may be joined by a second cut, which,
starting from its upper extremity, follows the lower margin
of the zygoma for about one inch.

The triangular flap thus marked out is reflected for-
wards. Care is taken not to damage any branches of the
facial nerve nor any lobe of the parotid gland.

Such fibres of the masseter as come into view are
separated from the zygoma, the capsule of the joint is
exposed and opened, and the condyle brought well into
view.

The neck of the condyle is now steadied by means of a
small blunt hook, and is divided either with a chisel or a
keyhole saw.

The condyle is then seized with forceps, and is twisted
out with the left hand, while the surgeon severs any re-
maining connections with a scalpel held in the right.
Throughout the whole operation it is important that all
instruments employed should be kept close to the bone.

Part V.

TENOTOMY.

———

INCLUDING OPERATIONS FOR THE DIVISION OF CONTRACTED

MUSCLES, LIGAMENTS, AND FASCIÆ.

The Subcutaneous Method. — The object of this method is to divide the tendon with the least disturbance of the surrounding parts and with the smallest possible division of the skin. Air is not admitted to the deep wound ; the risk of sepsis is thus minimised, and the surface punctured heals readily and surely. Before the introduction of the antiseptic method of treating wounds, the subcutaneous operation was all-essential. It is now much less important. At the present time it need only be carried out when convenient and possible.

In any case in which the tendon is not manifest or is difficult to discover, or in which its relations with nerves and vessels are complex and intimate, it is better to adopt the open method of the older surgeons, and to expose the area of the operation by a free incision.

Use of the Tenotome.—The tendon or band of fascia to be divided is usually unduly prominent, or can be readily made distinct. The tendon should, if possible, be so cut as to avoid opening a synovial sheath.

The tenotome should be lightly held, as one would hold a pen. The sharp-pointed instrument is carefully introduced close to the tendon, and makes a way for the blunt-pointed instrument. It is essential that it should make an ample passage for the blunt-pointed tenotome, and therefore the cutting point may need to be moved freely to and

fro in the region of the tendon. If this be not done, the blunt tenotome may have to be forced to its destination through tissues that have been merely punctured.

The sharp tenotome is withdrawn, and the blunt instrument introduced with the blade "flat"—that is, in a line with the line of the skin-wound.

The instrument should throughout be kept close to the tendon or band to be divided, and care must be taken to avoid damage to adjacent vessels or nerves. The breaking of the point of the tenotome against the bone is a not very infrequent accident.

As the tenotomes are being introduced the tendon should be only stretched to such an extent as is necessary to render its position distinct. It needs to be stretched to its utmost when its fibres are being divided, but this tension may be a little relaxed as the last strands are being cut. The tendon is divided with a sawing movement; it cuts with a creaking sound or sensation, and yields finally with a snap. A common source of failure after this operation is due to an incomplete division of the tendon.

The left forefinger should be kept upon the skin at the site of the operation, in order that the movements of the tenotomes beneath the integument may be followed and guarded.

PARTICULAR OPERATIONS.

Tibialis Anticus Tendon.—This tendon descends through the innermost sheath of the annular ligament, and, crossing the ankle-joint, astragalus, scaphoid, and internal cuneiform bones, is inserted into the inner side of the last-named bone and the base of the first metatarsal bone. The synovial sheath which accompanies it extends upwards for some distance above the level of the malleoli. A small bursa lies beneath the tendon as it crosses the cuneiform bone.

This tendon is usually divided as it is crossing the scaphoid bone, and consequently about one inch above its insertion. At this point it should be free of its synovial

sheath. The dorsalis pedis vessels lie to the outer side, with the extensor proprius pollicis tendon intervening.

In cases of congenital club-foot the tendon is displaced inwards, and is nearer to the malleolus. It is readily made prominent.

Operation.—The surgeon stands on the outer side of the limb in the case of either tendon. The assistant, who takes his place opposite to him, grasps the foot with one hand and the leg with the other. The foot is held in the position of extension and abduction, and the tendon is defined. The sharp tenotome is then entered vertically upon the outer side of the tendon and is pushed downwards until it has reached a point below the level of the tendon. The operator's left forefinger is kept over the skin upon the plantar side of the tendon, as a guard upon the instrument. The tendon is put on the stretch. The sharp tenotome is withdrawn, and the blunt-pointed one inserted in its place. After it has reached the depth acquired by the first instrument (whose track it exactly follows) the foot is relaxed, and the blunt point is pushed horizontally beneath the tendon, and may be felt on its plantar side. The tendon is once more put upon the stretch, and is divided by cutting upwards towards the skin. The left forefinger lies upon the skin over the edge of the knife, and forms a certain check to its movement. The surgeon cuts, indeed, upon the left finger, the skin intervening.

Tibialis Posticus Tendon.—The tendon becomes free of muscular fibres about the level of the tibio-fibular articulation. It grooves the back of the inner malleolus, running in the innermost compartment of the internal annular ligament. Behind the malleolus it is invested with a synovial sheath. The flexor longus digitorum tendon lies next to it (to its outer side), and is provided with a separate synovial sheath. Externally to this latter tendon run the posterior tibial vessels.

The tendon is usually divided above the point of commencement of its synovial sheath, *i.e.* about the level of the base of the malleolus, and therefore above the inner annular ligament. The tendon is here easily approached,

and is at some distance from the blood-vessels. Weis and Velpeau recommended division of the tendon at its insertion into the scaphoid bone. No advantage has been claimed for this method, and it is inapplicable to infants.

The tendon has been severed a little way below the tip of the malleolus. The selection of this point is to be condemned. The synovial sheath must be opened; the tendon lies close to the ankle-joint, and is in more intimate relation with the accompanying blood-vessels than it is at the spot usually selected.

Operation.—The surgeon stands to the outer side of the limb in the case of either tendon. The assistant faces him, and grasps the foot with one hand and the leg with the other.

The position of the tendon is made out, and the foot is held a little extended and abducted, and is so turned as to lie upon its outer side.

The surgeon seeks for that point on the inner surface of the tibia where the malleolus joins the shaft of the bone. He reaches this point by following the posterior margin of the malleolus. The spot in question will be about a finger's breadth above the tip of the malleolus in the infant, and about one and a half to two inches above that process in the adult. It is really on the shaft, and is above what would be called anatomically the base of the malleolus.

The surgeon fixes his left thumb-nail upon the margin of the bone, and enters the sharp tenotome vertically between the tibia and the tendon, using the nail as a guide. The instrument should be kept as near as possible to the bone. If properly inserted it will remain, as Mr. Heath has pointed out, fixed without any support of the hand. The tendon should not be too tightly stretched at this stage of the operation.

The fascia about the tendon should be freely divided by moving the point of the instrument to and fro, but without enlarging the skin-wound. Unless this be done, a proper way may not be made for the blunt-pointed instrument.

As the sharp tenotome is withdrawn the blunt one is introduced—the edge is turned towards the tendon, the

tendon is put upon the stretch and is divided by cutting
from the bone. The left forefinger, placed over the site of
the tendon, forms a guide and a guard. The tendon of the
flexor longus digitorum is usually cut at the same time,
and is often divided unconsciously.

The assistant should judiciously relax the strain upon
the tendon as its fibres are divided.

It is obvious that if little care be taken the knife may
cut through both the tendons, as through tightly-drawn
cords, and may wound the main artery beyond.

If the blood-vessels should be divided, a well-adjusted
pad of sterilised gauze must be at once applied to the spot.

Singularly little trouble appears to have supervened in
examples of this accident.

Parker's Operation—Syndesmotomy.—In cases
of congenital talipes varus in children Mr. R. W. Parker
is disposed to attach much more importance to the division
of ligaments and the plantar fascia than to pure tenotomy.

The site chosen for this combined section of ligaments
and tendons is a spot a little below and in front of the tip
of the inner malleolus, over the site of the astragalo-scaphoid
joint, and in the situation of the transverse mark near
the heel which is to be observed in severe talipes.
Two tenotomes are needed—an ordinary sharp-pointed
tenotome, and a curved one of sickle shape with a cutting
edge about half an inch in length.

The Operation.—The foot is so placed as to fully expose
its inner border, and is firmly held ; the position of the
tendons and the arteries is made out so far as is possible.

At the spot above mentioned the sharp tenotome is
entered. It should enter in front of the bifurcation of the
posterior tibial artery, and behind the posterior tibial
tendon. The knife is pushed forwards and outwards under
the skin until a spot on the dorsum is reached just internal
to the anterior tibial artery. The sharp instrument, which
has made a track merely, is withdrawn. The curved
tenotome is now inserted flat wise under the skin, and
follows the subcutaneous course already made until its
point can be felt over the tibialis anticus tendon. The

edge is turned towards the tendon, and is made to cut to
the bone. It severs the tendon, and as it is withdrawn is
made in like manner to cut the dense ligamentous tissue
already described. Just as it is being withdrawn it is made
to sever the tendon of the tibialis posticus.

During the introduction of the instruments the foot is
relaxed. During the cutting of the tissues it is put upon
the stretch, and the yielding of the divided ligaments and
tendons is made very evident.

Tendo Achillis. — This very powerful tendon
measures in the adult some four and a half inches in length,
three-quarters of an inch in breadth, and a quarter of an
inch in thickness.

It is best divided at its narrowest part, *i.e.* about
one inch above its insertion.

Operation.—The patient may lie upon the back, with
the body a little rolled over towards the affected side.

The foot is so turned as to lie entirely upon its outer
side, and a small cushion placed beneath the lower part of
the leg will carry the heel off the table.

The surgeon stands to the outer side of the limb in the
case of both the right and the left foot.

An assistant standing by his side holds the foot.
Another assistant may steady the leg.

The tendon, having been defined, is rendered a little
tense, but is not fully stretched. The sharp tenotome is
entered vertically at the inner margin of the tendon, and is
pushed downwards—in the present position of the foot—
until it has reached the outer edge of the tendon, where its
point can be indistinctly felt. The sharp-pointed instru-
ment is now replaced by the blunt, which follows the track
already made until its point can in turn be detected through
the skin. The instrument must be kept very close to the
tendon. The tendon is now put well upon the stretch, and
the cutting edge having been turned towards the surface,
the tense cord is divided with a sawing movement, the left
forefinger resting upon the skin over the site of the
operation.

The divided end separates with a snap, and unless care

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be taken just at the time when the tendon gives way, the integuments covering it may be divided by the suddenly-liberated knife.

Hamstring Tendons.—These tendons are most conveniently severed just above the line of the knee-joint, and on a level with the most prominent part of the condyles of the femur.

Biceps.—The patient should lie as far as possible upon the face, so that the popliteal space may be well exposed.

The surgeon may stand upon the inner side of the limb in the case of either the right or the left tendon. If he place himself to the outer side of the extremity, he will face the patient when dealing with the left leg, and have his back to the patient when dealing with the right.

The leg is steadied by an assistant. With a sharp-pointed tenotome a puncture is made directly over the tendon, and the instrument is passed vertically downwards on the inner side of the tendon, and is withdrawn when it has passed a little way beyond it.

The blunt point is now introduced, and, following the same line, is passed vertically between the tendon and the nerve. When it has just passed beyond the tendon the blade is turned outwards, the handle brought as nearly horizontal as possible, and the point passed beneath the biceps until it may be felt upon the outer side.

The tendon is then divided by cutting towards the skin, which is guarded with the left forefinger in the usual way. During the introduction of the tenotomes and the cutting of the tendon the biceps should kept upon the stretch. As the knife is withdrawn the limb should be flexed.

If care be not taken, the knife may slip through the skin when the tendon gives with a snap.

In the conditions for which this operation is usually performed the contracted biceps tendon is drawn away from the nerve, and a wider interval than the normal separates the two structures. The safest plan, however, unless the nerve can be plainly felt through the skin, is to make a small incision, so as clearly to expose both nerve and

tendon. The nerve being then held aside, the tendon is divided.

Both in the class-room and in practice I have seen a prominent and cord-like ilio-tibial band divided in the place of the biceps.

In some thin and muscular subjects the lower portion of this fascial band may feel very tendon-like.

Numerous contracted bands of fascia may come into view after tenotomy of the biceps for contracted knee. Some may need division. They are, however, better left alone, as they usually yield under extension, and in dealing with them by tenotomy unexpected vessels may be wounded.

Semitendinosus and *Semimembranosus.*— The same observations as have been applied to the biceps apply generally to these tendons. They are most conveniently divided exactly opposite the spot selected for tenotomy of the biceps.

The tenotome is introduced upon the outer side of the tendon, and is passed beneath it. The steps of the little operation need not be repeated.

In one case Mr. Jacobson met with " most profuse " hæmorrhage in dividing the semimembranosus tendon in a girl of sixteen. He considered that the bleeding— which was checked by pressure—proceeded from the superior internal articular artery.

Dupuytren's Contraction.—The exact anatomy of the palmar fascia should be borne in mind, and especially the manner in which the digital processes of the fascia are disposed of, and the connections of the ultimate slips of the fascia with the integument of the fingers. It will be remembered that each division of the palmar fascia sends five slips. 1. A central one to the sheath of the flexor tendons : 2. One on either side to the skin at the cleft of the fingers. 3. One to the superficial transverse ligament on either side. `In Dupuytren's contraction all these may be hypertrophied.

Open Excision of the Contracted Bands.—The patient's hand must be sedulously cleaned with alcoholic

solution of carbolic acid, etc., special attention being paid to the deep furrows caused by the contraction, in which dirt is apt to collect and lie concealed.   An Esmarch's tourniquet is convenient, and should be applied above the wrist.   The hand being held by an assistant with the palm upwards and the fingers extended as far as possible, the surgeon makes a longitudinal incision directly over the main bands of fascia, and if necessary adds two short transverse cuts at either end.   The skin is carefully reflected on either side, it being very easy to buttonhole it. The fascial band projects forwards from the digital vessels and nerves, but it is necessary to avoid dividing these at the same time as the fascia.   The band of the latter, having been cut through at the upper end of the incision where it is a single tough cord, is then drawn out, and with its various prolongations again divided below.   It is at this point that the digital vessels and nerves are in most danger.   From one to two inches of the fascial band is removed, and the more thoroughly its divisions are dissected out the better will be the result.   Indeed, it is well to dissect away all fascial tissue exposed which feels distinctly hard to the touch.   If both ring and little fingers require to be operated on, it is better to turn back a longitudinal flap.   After the tourniquet has been removed and bleeding stopped the wounds are sewn up with fine silkworm-gut. The incisions are apt to gape a little, and sutures should not be applied where they cause too much tension.

The fingers are put up on a splint in the extended position.   The wounds will probably be healed in a week, but before this time the phalangeal joints should be flexed every day so as to prevent their becoming stiff.

Division of the Sterno-Mastoid Muscle.—The sterno-mastoid muscle is encased in the cervical fascia, and to obtain the best result in operating for wry-neck it is essential to divide not only the muscle, but its contracted sheath.   The sternal portion of the muscle usually appears to be more contracted than the clavicular, but it will almost always be found necessary to divide both.   The division should be carried out a short distance above the clavicle,

and not close to that bone, and it should be done by the
open method, for by this procedure alone is it possible to
divide the muscle and fascia completely without risk of
injury to the veins.

Operation.—A general anæsthetic is given, the head and
shoulders are well raised, the surgeon stands on the same
side as that of the contracted muscle. By means of two
incisions, one over the anterior edge of the muscle, the
other parallel to and a little above the clavicle, the latter
running across both heads of the muscle, a small triangular
flap of skin and superficial fascia is turned outwards. The
assistant, who steadies the patient's head, makes the con-
tracted muscle as tense as possible whilst the surgeon
steadily divides first the sternal and then the clavicular
portions and the fascial band. The division is done gradually
from before backwards with a blunt-pointed tenotome or
fine scalpel, and the large veins are looked for and care-
fully avoided. The posterior part of the sheath will usually
be found to require division or stretching. By this
deliberate and open division the risk of recurrence of the
deformity is to a great extent avoided, and the necessity for
wearing irksome apparatus largely dispensed with. The
small flap of skin is fixed in place with a few fine silk-
worm-gut sutures, and dressed with gauze and collodion
or some other light and dry dressing.

Part VI.

PLASTIC SURGERY,

CHAPTER I.

Operations For Hare-lip.

SINGLE HARE-LIP—THE USUAL OPERATION.

Instruments Required.—A fine, narrow, sharp-pointed scalpel or small tenotome (for the less simple methods a slender double-edged knife is useful); slender-bladed dissecting forceps with toothed points; small sharp-pointed scissors curved on the flat; straight blunt-pointed scissors; artery forceps; sequestrum forceps with broad ends protected by indiarubber; needles and sutures; needle-holder; a gag and tongue forceps may occasionally be useful; small fine sponges.

The Operation.—The infant is wrapped up in a towel or sheet, so that the head alone projects. In this mummy-like guise it is easily handled, and the movements of its limbs are restrained.

The patient lies supine, with the head well raised and supported upon a sand-bag or firm cushion.

The surgeon faces the patient, or stands to the right-hand side. An assistant places himself behind the child, and steadies the head, while at the same time he compresses the facial arteries against the lower jaw. The administrator of chloroform will stand upon the left of the table.

First Step.—Grasping the upper lip, the surgeon proceeds to separate it—upon each side of the gap—from the

maxilla. This can best be effected by means of small sharp-pointed scissors curved on the flat. The scissors must be kept close to the bone. It may be necessary to detach one ala of the nose from the maxilla. In any case the detachment should be sufficiently free to allow of the margins of the cleft coming together readily and without the least tension.

If the maxilla of one side project inconveniently beyond its fellow, it should be forcibly bent back with sequestrum forceps, the blades of which are protected by indiarubber.

Second Step.—The edges of the cleft are pared. The lower angle of one flap of the lip is seized with fine-toothed dissecting forceps, is drawn upon, and the margin is then pared with the narrow scalpel. The incision for paring the edge should commence above, at the upper angle of the gap, and, descending obliquely, should curve inwards, when the red margin or lower angle of the flap is nearly reached (Fig. 84).
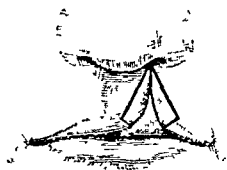
Fig. 84.—OPERATION FOR SINGLE HARE-LIP.

When one side has been treated, the other is dealt with.

Or the lip on one side having been made tense, it may be transfixed in its whole thickness from before backwards by the narrow scalpel. The point is entered just above the lower angle of the flap, and, the edge being directed upwards, the knife is made to cut towards the upper angle of the gap, to follow that angle, and finally to descend upon the other side. The knife is then withdrawn, and is not allowed to cut its way out. The piece isolated by paring will still be attached to the lip at both ends, and its detachment may be left until some of the sutures have been introduced, and until the amount of tissue required for the formation of a good free margin to the new lip has been ascertained.

In any case the paring must be freely, liberally, and evenly carried out. The raw surface should be as wide as possible, especially below.

ᵞDuring this step there may be much bleeding, which must be checked either by pressure upon the facial arteries, or by the compression of each coronary artery at the angle of the mouth between the thumb and finger of an assistant. The latter procedure is the more efficacious, but the operation area is encroached upon and disturbed, and in the place of an assistant's fingers some form of hare-lip compression forceps may be used.

Third Step.—The gap is now closed. The assistant who holds the head presses the cheeks together with his fingers, so that the two raw surfaces are approximated. The approximation must be exact. The margins are then united by means of fine silkworm-gut sutures carried on straight needles.

The first suture should involve the middle of the lip, the next the lower portion, and the third the segment near the nostril. These are the three main sutures. They should include the whole thickness of the lip, excluding the mucous membrane only ; and the first or median suture, if properly introduced, should command the coronary arteries when it is finally drawn tight.

It is well to pass the three needles one after the other, and to leave them in the tissues until it has been ascertained that the best possible approximation of the raw edges has been obtained. From the manner in which the cheeks are held, the relations between the two sides of the cleft may be disturbed. The three needles act as three temporary pins.

After the surgeon is satisfied that the best possible adjustment has been obtained (and one or more of the needles may have to be re-introduced before it is obtained), the sutures are drawn through, tied in the usual way, and cut moderately short.

The three stitches are introduced about one-third of an inch from each side of the cleft.

Two, three, or more sutures are now inserted at the free margin of the new lip, especially upon its inner or alveolar aspect. These are composed of the finest silk, and are passed by means of slender curved needles held in a needle-holder.

Some of these fine stitches may be required along the main wound, and one will usually be needed for the margin of the nostril.

So-called hare-lip pins are never required, nor is strapping ever needed to support the wound.

The wound having been well dried with small pieces of fine sponge, the surface is dusted with boracic acid or iodoform, and is covered with a strip of soft gauze. The gauze may consist of several layers, and the component strip must be cut to exactly fit the part, and should not extend on to the cheek. A very slender piece of strapping will keep the gauze in place. Instead of plain gauze, gauze and collodion, or a solution of celloidin (5 parts) in ethylic alcohol and ether (of each 10 parts), may be used. The latter dressing fits accurately, and is not irritating.

Fig. 85.—OPERATION FOR DOUBLE HARE-LIP.
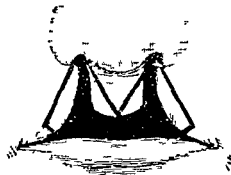
DOUBLE HARE-LIP.

The operation required in cases of double hare-lip is of the same character as that already described.

In many instances the defect is more easily remedied when it is double than when merely a single gap exists. In the most favourable forms of double hare-lip the sides of the cleft are symmetrical, and are, moreover, more nearly parallel than is the case in single hare-lip.

A malplaced pre-maxillary bone is the most troublesome complication met with in dealing with this deformity.

The skin over the pre-maxillary bone is freed from its deep attachments behind, and its edges are pared so that it receives a U- or V-shaped outline. The margins of the lip on each side are then pared in the manner already described (page 271). The portions of the lip may or may not need to be freed from their attachments (Fig. 85). The raw edges are finally united with silkworm-gut sutures. Owing to the small size and the shape of the central piece, the resulting wound is more or less Y-shaped.

In order to avoid the notching which not unfrequently occurs in the median line, when cicatrisation has taken place after this operation, thick flaps with square ends may be cut from each margin of the main cleft. These flaps have their attached ends downwards. They are united to the raw margins of the central segment above, and to one another along, what is now the new margin of the lip. The segments of the lip will need to be freed from their deep connections on each side of the cleft.

When the pre-maxillary bone projects strongly forward some surgeons remove it entirely, but the best course is to retain it.

Very usually the bending back of the bone is resisted by the cartilaginous vomer of children, and the elasticity of that structure causes the fragment to be again protruded when the pressure is removed.

In such a case a portion of the vomer may be excised subperiosteally. An incision is made along the free border of the septum, leaving its arteries intact : the periosteum and mucous membrane are then elevated on either side, and a triangular segment is excised from the vomer. The os incisivum may now be pushed into place, and may be retained, if needed, by one or more sutures.

The bleeding in this operation is apt to be free, unless the subperiosteal method be closely adhered to.

CHAPTER II.

Operations for Cleft Palate.

Order of Operation.—The union of both parts of the palate should be attempted at one operation.

Sir T. Smith makes one proviso. " When the bringing together of the whole cleft in one operation would necessitate so free a division of the soft parts as to endanger the vitality of the flaps, it is advisable to close first that part of the cleft that can be most easily approximated, whether it be the hard or the soft palate. This, if successful, will secure for the remaining portion a large supply of blood in the subsequent operation."

Instruments and Suture Material.—The *instruments* required :—Two sharp-pointed tenotomy knives in long and slender handles, for paring the edges of the cleft. A blunt-pointed knife of the same kind, for making lateral incisions to relieve tension. Two pairs of long, slender-bladed forceps, one serrated and one with tenaculum points. A fine hook. A pair of small, sharp-pointed scissors curved to a quarter circle, for dividing the connection of the soft palate with the nasal mucous membrane at the posterior margin of the hard palate. Small blunt-pointed scissors, curved on the flat, for the sutures, etc. Palate raspatories curved as an aneurysm needle, and another raspatory very slightly curved. Smith's raspatories or Ollier's instrument are admirably suited for the purpose. Two needles on long handles, and with eyes at the point for the fine sutures. Some simple curved needles, and a plain needle-holder, may be useful. Smith's, Mason's, or other gag.

For introducing silkworm-gut sutures rapidly Fitzgerald's needles will be found useful.

A loop of the gut is held in the needle, which has the

slot directed towards its point. The needle is then thrust through one side of the palate, and the other needle passed unthreaded through a corresponding point on the opposite side of the cleft. With this second needle the loop is caught in the slot, and both needles are then withdrawn. With slight practice the operator will find this method to be one of the most rapid.

A number of small Turkey sponges in sponge-holders are required, and the necessary material for the various sutures.

With regard to the suture material, much must depend upon the custom of the individual surgeon. Horsehair answers admirably for the uvula, and for the lower and flaccid part of the velum. It is distinctly not suited to any part where there is tension. The sutures should be of full length, should be carefully selected, and should be softened before the operation by immersion in warm sterilised water. Horsehair sutures should be tied in three knots.

For the principal sutures—for those that have to bear strain—silkworm-gut answers admirably. It causes, as a rule, no irritation. It should be prepared by immersion in hot water. The fine gut should be used, as it can be readily knotted, a single "surgeon's" knot being employed.

Position of the Patient.—The upper part of the body must be well raised, and the head be placed sufficiently high to prevent the surgeon from stooping. The head should rest upon a hard cushion, or be received in a depression in a sand-bag. It must be thrown well back. The table should be narrow. The surgeon stands on the right, facing the patient.

OPERATION ON THE SOFT PALATE.

The gag having been introduced, the first step is to pare the edges of the cleft. The tip of one half of the uvula is seized with the tenaculum forceps, and is drawn upon so as to make the palate tense. With a sharp-pointed knife the edge is now pared from below upwards, *i.e.* from the free

margin of the velum towards the hard palate.   The knife
may follow the anterior angle of the cleft (assuming the
hard palate to be sound), and may return in the opposite
direction along the other margin of the cleft, that side of
the velum being made tense in turn.

The whole of each side of the cleft must be well and
liberally freshened.   The anterior angle of the cleft and the
tip of the uvula are especially apt to escape the knife.   The
raw surface should be wide, and of even width throughout.

Scissors should never be used to freshen the edges.

There will probably be no need for the flaps to be again
touched with the forceps when this stage has been com-
pleted.

The next step is the passing of the sutures.   They should
be introduced from below upwards.   The first suture is
passed through the halves of the uvula, and the two ends
are held in a pair of Wells's forceps, so that it may be used
to make the edges tense, and thus avoid any handling of
the palate with forceps.   The same course is adopted with
the ends of each suture, so that when the moment arrives
for tying them all there can be no confusion between the
various sutures.   Each Wells's forceps grasps the corre-
sponding ends of a single suture.

The sutures must be placed at a sufficient distance from
the margin of the gap to secure a good hold, and their
number and arrangement must depend upon the degree of
tension at any particular point.

If the cleft be narrow, the sutures can be passed without
difficulty.   If it be wide, some special method may have to
be adopted.

The following is the most convenient :—A very long
suture has a needle threaded at either end of it.   One
needle is passed through the left flap of the palate from
behind forwards, and the other through the right flap in the
same direction.   The first needle passed must be held by
an assistant while the other is being introduced.   This is
practically the method often adopted in closing an abdominal
incision.   The needles employed should be small and curved,
and must be passed by means of a simple needle-holder.

Needles of various curves should be at hand.   In no operation is a complex needle-holder more out of place than in this.

" When there is too much tension to admit of the sutures being tied at once, they should all be passed, and, being held as described above, longitudinal incisions may be made on either side parallel to the cleft and just internal to the hamular process, avoiding the immediate neighbourhood of the posterior palatine foramen.   Sufficient relaxation being obtained, the remaining sutures are tightened up."

If after the lateral incisions have been made the tension is not amply relieved, it is well to introduce a slender-pointed raspatory or vivisector's tool through the incision, and with it to detach the muscular and tendinous structures from the hamular process.   I have found such a step always to answer its purpose completely.

Throughout the operation, bleeding must be checked by gentle pressure with a sponge in a holder.   The sponge should, however, be used as little as possible.   The indiscriminate and persistent dabbing of the palate with a sponge tends to excite movement of the palatal and pharyngeal muscles, to produce vomiting and coughing, and to greatly increase the flow of saliva.

OPERATION ON THE HARD PALATE.

The flaps consist of all the tissues down to the bone. ·

In order to avoid tension when the sutures are secured, it is necessary in all cases to lift up with a raspatory the flaps from the cleft outwards for a considerable distance, in addition to making an incision just behind the hamular process to free the soft palate.   Particular attention must be paid to the junction of the hard and soft palate where the tissues are most firmly attached to the bone along the posterior edge of the hard palate.   At this spot partial failure to unite is often met with in otherwise successful cases.

The blood supply of the palate, both hard and soft, is almost entirely derived from the posterior palatine artery—

a branch descending from the internal maxillary. The posterior palatine vessels emerge through the bone just internally to the socket for the last molar tooth, and the branch for the hard palate courses forwards to the incisive foramen, parallel to the alveolar margin (*see* Fig. 86).

The dotted line in the figure shows where the incision
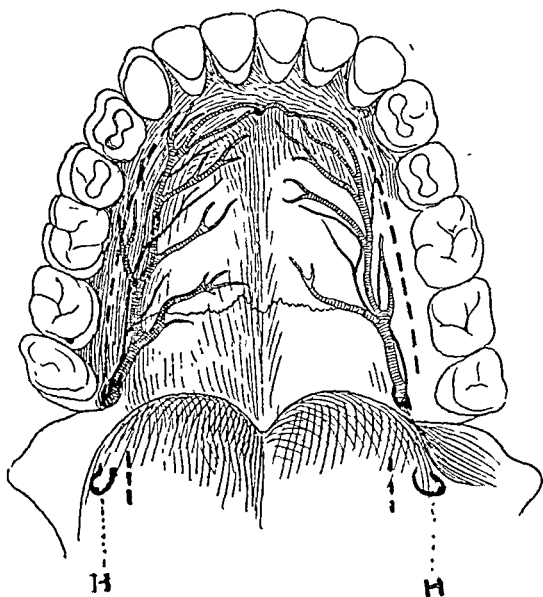
Fig. 86.—THE PALATINE ARTERIES IN RELATION TO THE OPERATION FOR CLEFT PALATE.

The dotted line on either side between the gum and the palatine artery and nerve shows where the incision should be made in order to displace these inwards uninjured in the flaps. H H, Hamular processes. A dotted line to the inner side of each hamular process indicates how the tensor palati may be divided so as to relieve tension.

should be placed—*i.e.* it must be just internal to the alveolar border and external to the groove for the artery already referred to. The incision goes right down to the bone, but should stop short in front of the last molar tooth,

lest the artery should be wounded as it leaves the posterior palatine foramen.

The cases of serious and sometimes fatal hæmorrhage following the operation have been those in which the latter accident has occurred.

An additional incision will be required through the soft palate internally to the hamular process.

The **steps of the operation** are as follows :—

1. The edges of the cleft are carefully pared along its whole length on either side, the soft tissues being raised from their attachment to the hard palate and nasal septum.

2. One lateral incision just within the alveolar margin (*see* Fig. 86) is now made, and with a curved raspatory the whole of the soft tissues are carefully detached as far inwards as the edge of the cleft. At the back the raspatory is made to lift off from the bone that part of the soft palate where it joins the hard. This is best done from the cleft. The bleeding in this stage may have been considerable ; it should be checked by pressure (made by the assistant with a sponge mounted on holder), whilst the operator proceeds to repeat the lateral incision on the opposite side. This incision is made in one case from before backwards, in the other from behind forwards. Sponge pressure will now be made on both sides, whilst the anæsthetic is resumed. The fauces need to be kept clear of blood by sponging, but this should be as sparing as possible, and done with the utmost gentleness.

3. The sutures are now introduced by one of the methods already described. The first will be passed through the soft palate at the base of the uvula. Traction made on this will steady the two halves, and ensure the others being placed at regular intervals. Fine silkworm-gut

is used, and the two ends of each suture are held outside the mouth in a Wells's forceps.

The sutures should be placed at fairly close intervals, about 8 to 10 mm. apart.

4. Each suture is tied in order, but before doing so the surgeon relieves tension as far as possible by the use of the raspatory, and by two short incisions through the soft palate made just within the hamular process. Especial attention should be paid to the extreme anterior end of the cleft, and to the point opposite to the junction of hard and soft palate. The knots made are single surgeon's ones, so that the ends lie evenly against the palate and cannot irritate the tongue.

Note.—In the usual description of the operation the lateral incisions are placed more internally than above described—*e.g.* midway between the cleft and the alveolus. As Tillaux pointed out, the branches of the palatine artery are then cut across. Placing the incisions close to the alveolus presents no special difficulties, and diminishes the risk both of hæmorrhage and of sloughing of the flaps.

Part VII.

OPERATIONS ON THE NECK.

CHAPTER I.

TRACHEOTOMY AND LARYNGOTOMY.

I.—TRACHEOTOMY.

THE operation is said to be "high" or "low," according as the trachea is opened above or below the isthmus of the thyroid body. In the adult the isthmus crosses the second and third rings of the trachea, and sometimes even the fourth. In the child the isthmus is narrow, and is usually somewhat higher up. It may even lie on the crico-tracheal membrane. The high operation is always to be preferred; it alone is described in the account which follows.

Instruments required.—Scalpels; dissecting, artery, and pressure forceps; toothed forceps (Liston's artery forceps without the catch answer the purpose); sharp hook; blunt hook; scissors; needles; tracheotomy tubes and tapes. To these may be added a gag and tongue forceps, small wound retractors, and feathers to clear the tube when first introduced.

A good tracheotomy tube should be of simple construction, should be easy to introduce, should be as large as the diameter of the trachea will admit, should lie exactly in the long axis of the windpipe without touching the tracheal wall with its extremity, should have a movable shield so that it is disturbed as little as possible, and the inner cannula should be capable of being easily inserted and removed.

1. **Position of the Patient.**—The child is enveloped in a thin macintosh sheet, and is placed close to the right edge of the table. The surgeon stands by the same side of the table. The neck is supported on a firm sand-bag of suitable size. When the child is ready the head should be drawn well over the upper end of the table, so that the vertex is turned nearly towards the ground.

The sand-bag will be placed close to the upper edge of the table, and over it the child's head is extended in this extreme manner.

This position renders the structures on the front of the neck tense, steadies the trachea, draws as much of that tube up into the neck as is possible, and brings it a little nearer to the surface. The superficial veins are, moreover, a little emptied of their blood by this attitude of over-extension.

The anæsthetist stands at the head of the table, and the important duty should be imposed upon him of holding the head steady, and of keeping the chin most rigidly in a line with the sternal notch. If the head be allowed to fall over to one or other side, the position of the middle line is lost.

An assistant stands by the side of the anæsthetist, and will, later, take charge of the sharp hook.

2. **Exposing the Trachea.**—An incision is made with a sharp scalpel very precisely in the median line of the neck. Its length will be about one inch or an inch and a half, and its upper extremity will be at the upper border of the cricoid cartilage. Before making this cut, the surgeon should have accurately defined the position of the thyroid and cricoid cartilages. The latter cartilage is often difficult to detect in stout subjects, and especially in young infants.

The skin and the trachea are steadied with the left hand while the cut is being made.

The right hand must be unsupported. If the operator rests his wrist upon the upper part of the child's chest, as he is tempted to, he will find that the rapid movements of the thorax in laboured breathing render that part no proper place for support.

The surgeon, still fixing the trachea and soft parts with the left hand, cuts deliberately in the middle line through the subcutaneous fat and the anterior layer of the cervical fascia. The sterno-hyoid and the sterno-thyroid muscles are reached, and the interval between them is opened up. All this is done by successive clean cuts.

The surgeon now separates the muscles, using the dissecting forceps and the handle of the scalpel for the purpose.

Keeping still to the middle line, and once more steadying the trachea, he divides cleanly, and by cautious cuts, the fascia covering that tube.

At this stage veins will probably be encountered, and may be displaced to one or other side by the handle of the scalpel. The isthmus of the thyroid will be seen, and is by a like means displaced downwards. If necessary, it may be drawn and held downwards by a small blunt hook.

Fig. 87.—OPERATIONS ON THE LARYNX AND TRACHEA. (*Tillmans.*)

I, Sub-hyoid Pharyngotomy; II, Thyrotomy; III, Laryngotomy; IV, Cricotomy; V and VI, High and low tracheotomy. *Hy*, Hyoid bone; *Thy*, Thyroid cart.; *Cri*, Cricoid cart.; *T. gl*, Thyroid gland.

The surgeon now feels for the tracheal rings with his left forefinger. He should be satisfied that the tube is well bared, and he should be able to see the white rings themselves. This is absolutely essential before the trachea is incised.

3. Opening the Trachea.—A small sharp hook is now introduced into the cricoid cartilage, and is given to the assistant to hold who stands at the head of the table.

The hook is kept precisely in the middle·line, and is used to fix and draw forwards the cricoid cartilage, and to render the trachea tense. The assistant must give a little play to the hook, as the larynx moves with each inspiration.

With the left forefinger the operator feels the upper rings of the trachea, and with a slender scalpel, held with the edge towards the patient's chin, he stabs the trachea in the median line some three rings below the cricoid, and cuts up on to the hook (v, Fig. 87).

The noisy rush of air entering and escaping through the wound, the coughing of the child, and the expulsion of mucus and membrane bring about a moment of confusion. The hook must not be removed. It remains as an easy guide to the median line of the trachea and the site of the opening therein. The opening must be free.

If the hook be not used, the operator may miss the slit in the trachea he has already made, and may, in his haste, proceed to make another.

4. Introduction of the Tube.—The right margin of the cut in the trachea should be lightly seized with the toothed forceps, which are held in the left hand ; and while the opening is thus, for a moment demonstrated and fixed, the tube and pilot are slipped in. If the forceps be employed as directed, the tube can be introduced with certainty and ease. If no such precaution be taken, much time may be wasted in driving the pilot hither and thither in search of the slit-like opening, which is very easily lost. The depth of the wound, the quantity of blood and mucus which may fill it, and the movements of the trachea, may readily cause the site of the opening to be lost, especially if the trachea has not been well exposed and the fascia freely divided.

It will usually be found more convenient to restore the child's head to the erect position before the tube is intro-

duced. When the tube is in place—and not before—the sharp hook is removed.

The tube is secured in place by tape, and the wound below the tube is brought together by a suture or two of silkworm-gut. A piece of lint properly shaped and smeared with a weak iodoform ointment is placed under the shield of the tube, and is made to cover and protect the wound.

Rapid and efficient sponging with small pieces of fine Turkey sponge is of great service throughout the operation.

Tracheotomy by Bose's Method.— A vertical incision is made in the median line. It commences opposite the centre of the thyroid cartilage, and is continued downwards for about one and a half or two inches. The incision is carried down to the lower part of the thyroid cartilage and the upper part of the cricoid. The soft parts being held aside by retractors, a transverse incision is made along the upper border of the cricoid cartilage in such a way as to divide the layer of the deep cervical fascia which lies in front of the trachea and which holds the thyroid isthmus. A blunt director is now introduced through this transverse incision, and by its means the fascia and the isthmus, together with all the veins connected therewith, are fully separated from the trachea. A broad, curved hook is now introduced, and the detached fascia, together with the other soft parts, is drawn downwards, leaving the trachea quite bare. The cricoid cartilage is now fixed by means of a double-pointed sharp hook, and the tracheal rings are incised in the usual way.

This method has much to commend it. It is simple and easy of performance. It involves some expenditure of time, and some damage may be done to adjacent structures by the director if care be not used. Veins are readily torn through by this instrument. If cautiously performed, the operation has distinct claims to be called "bloodless."

Comment.—*Quâ* operation, tracheotomy must be regarded as an easy and simple procedure. Those

who have performed it only upon the dead subject
must be at a loss to understand the terrible possibilities
with which the introduction of a tracheotomy tube appears
to be surrounded.   In the adult, it is true, the operation is
but rarely in any way difficult or complicated ; in an infant
with a short, stout neck, on the other hand, it may be
attended with not inconsiderable difficulties.

For the accidents which so often occur during tracheo-
tomy, the hurry and excitement of the operation, and the
fear that the child is ceasing to breathe, are in the main
answerable, and not the anatomical conditions of the opera-
tion itself.

It must be expected that in almost every case there
will be free venous bleeding.   While it is well that the
hæmorrhage should be checked before the tube is intro-
duced, lest blood find its way into the lung, yet too long a
time should not be devoted to attempting to secure the
vessels.   As soon as the tube is introduced, air enters the
lung more freely, the right side of the heart is relieved, and
venous bleeding, which before was very copious, ceases
almost immediately.

The cervical fascia must be well and cleanly divided.
The tube has many a time been introduced between the
trachea and the imperfectly divided fascia, the operator
being under the impression that it has been inserted into
the windpipe.   No air, however, escapes.

In cases where an extensive membrane exists, it may
escape division when the trachea is opened, and the tube
may then be inserted between the membrane and the
tracheal wall.   In this case, also, no air escapes from the
instrument.

In most cases of tracheotomy performed by a novice,
or carried out with undue haste, it will be observed that
the time of the operation is more taken up by introducing
the tube than by finding and incising the trachea.

If the hook and the toothed forceps be used as de-
scribed, all bungling over the insertion of the tube may be
avoided.   Some time may be spent in endeavouring to find
the slit which has been already made in the trachea.

The following rules should be observed :—

1 Let the chin be kept rigidly in a line with the sternal notch.

2. Cut only in the middle line.

3. Avoid anxious assistants with retractors.

4. See the white rings of the trachea, and feel them bare before plunging the knife into the windpipe.

5. Avoid hurry.

II.—LARYNGOTOMY.

Laryngotomy, or the artificial opening of the larynx through the crico-thyroid membrane, is occasionally performed as a substitute for tracheotomy. The operation has the advantage of being very rapidly and very easily carried out. It is quite inapplicable to children under thirteen years of age, owing to the narrowness of the crico-thyroid space. The great drawbacks of the operation are the proximity of the vocal cords and the difficulty of adjusting a suitable tube. Laryngotomy is totally unsuited to cases in which a tube has to be long worn.

The Operation.—The head is well extended over a sand-bag or hard cushion, and is kept fixed, with the chin in a line with the sternal notch. The anæsthetic selected is chloroform. The anatomical details of the part must be made out, and the crico-thyroid space defined.

The larynx is lightly steadied with the left hand, while the surgeon makes a vertical median incision, about an inch and a quarter long, over the lower part of the thyroid cartilage, the crico-thyroid space, and the cricoid. The fascia having been divided, the interval between the sterno-thyroid and crico-thyroid muscles is appreciated, and is widened with the handle of the scalpel.

The crico-thyroid membrane is exposed, and is divided horizontally, just above the cricoid cartilage.

Care must be taken that the air-passage is well opened, as it is not difficult to pass the tube downwards between the crico-thyroid membrane and the mucous lining of the windpipe.

The laryngotomy tube is shorter than that used for tracheotomy, and is oval on section.

Some surgeons advise that the membrane be opened by a vertical incision, on the grounds that the operation can, if desired, be extended by dividing the cricoid cartilage, and that in the horizontal incision damage is usually inflicted upon the crico-thyroid muscles, and possibly also upon the lateral crico-arytenoid muscles.

Thyrotomy.—By thyrotomy is understood the division of the thyroid cartilage in the median line (Fig. 87, II), so as to gain access to the interior of the larynx. The operation is carried out in order to remove certain laryngeal growths, and certain large or impacted foreign bodies, especially such as have found their way into the ventricles.

The operation involves a great danger of permanently interfering with vocalisation, and in the treatment of morbid growths it is only employed when the intralaryngeal method of removal cannot be effectually carried out.

Thyrotomy offers a rapid and ready means of entirely eradicating laryngeal growths, and those advantages may be claimed for it which are ascribed to other radical operations.

The Operation.—The head is extended over a hard cushion or sand-bag, and is firmly held with the chin in a line with the sternal notch. The shoulders are raised. Chloroform is the anæsthetic administered. A preliminary laryngotomy or tracheotomy is carried out. The position of the opening for the tube will depend upon the nature of the case, the length of time the tube will probably have to be worn, and upon other circumstances. If the operation threatens to be extensive, as in dealing with large growths, a tracheotomy will be found to be the more convenient; but in such an operation as is carried out for the removal of a foreign body, a laryngotomy may be selected.

If much hæmorrhage is anticipated, as will be the case in dealing with extensive papillomata, the trachea must be plugged. This may be effected by a tampon, such as Trendelenburg's tracheotomy tampon, or by gently plug-

K

ging the trachea on either side of the tube with a piece of fine sponge properly shaped and attached to a long silk thread.

The incision is prolonged upwards in the median line, and the skin and subcutaneous tissues are divided down to the cartilage. The incision will extend over the cricoid and thyroid cartilages, the crico-thyroid space, and some part of the thyro-hyoid space.

The thyroid cartilage is divided accurately and carefully in the median line, the thyro-hyoid and crico-thyroid membranes being also cut if needed.

The division of the cartilage should be effected from above downwards, and from without inwards. In young subjects, and in females who have not passed middle life, the section may be accomplished by a small but stout knife. In aged subjects, in whom the cartilage will be calcified, a fine saw may be needed to effect a division. Bone forceps should never be employed.

By means of two small sharp hooks the two alæ are now drawn aside, and the interior of the larynx is exposed. In old subjects it may be necessary to make transverse incisions in the crico-thyroid and thyro-hyoid membranes, close to their respective cartilages, before the fullest view desired can be obtained.

The foreign body may now be extracted or the growth removed.

In dealing with papillomatous masses, the bulk of the growth may be crushed off with broad forceps, and the remainder removed with scissors, aided by Volkmann's spoon. The surface left by the removal of the tumour may then be touched with a saturated solution of chromic acid.

Finally, the two portions of the thyroid cartilage are united by two or three fine tendon sutures, and the wound in the skin is closed.

CHAPTER II.

Excision of the Thyroid Body.

Complete Excision.—This term is used in an elastic manner—for complete excision in the sense of removing the whole of both lobes and the isthmus should never be performed, because of the great risk of the gradual development of a " cachexia strumipriva." This condition resembles myxœdema, and is inevitably fatal in its ending. Hence, some portion of the thyroid gland should always be left behind ; it will hypertrophy, and prevent this unfortunate result of the excision. The method of operating here described is that known as Kocher's. The patient lies upon the right-hand side of the table, with the shoulders well raised and the head extended over a large sand-bag or hard cushion. The chin should be kept in a line with the sternal notch, and the head be well fixed.

An incision is made in the median line from the sternal notch to the upper limit of the bronchocele. From this point two lateral incisions are made upwards and outwards, one on each side. They are directed towards a point a little below the angle of the jaw, and when the cutaneous cut is complete it will have the outline of the letter Y. If the tumour be much more extensively developed on one side than on the other, the upper or oblique incision may be limited to the affected side. In any case the incision must not be spared. A primary requirement is that the tumour be very freely exposed. The lateral or oblique cuts will usually pass over the anterior borders of the sterno-mastoid muscles.

The platysma and fascia are divided. Any veins which are met with are secured between two ligatures of catgut, and divided. The sterno-hyoid and sterno-thyroid muscles

will be found to be stretched over the goitre. These struc-
tures will probably be much thinned and very altered in
appearance.

The surgeon must make his way down to the gland, and
must convince himself that he has opened up the plane of
connective tissue beneath these muscles, and is not wander-
ing aimlessly over their outer surface.

The sterno-hyoid, sterno-thyroid, and omo-hyoid muscles
will need to be divided in whole or in part. They should,
however, be respected as far as possible, and drawn to the
outer side of the tumour.

It may be necessary even to cut one or both of the
sterno-mastoid muscles. The operator must trust but little
to retractors, but must rather aim at obtaining the fullest
view of the bronchocele by dissection.

The muscles named will very often be .closely adherent
to the tumour, and in clearing them away the scalpel must
be used very sparingly.

No instrument is more serviceable in this stage of the
operation than a broad periosteal elevator. Its point is so
blunt that it can do little damage, and its configuration is
admirably suited to peel the tissues away from the capsule.
This must be done with great care. The elevator is made
to work its way beneath the muscles and the fascia, and
when the precise relations are clear the tissues are divided
over the elevator as over a director. In effecting this
exposure of the goitre a pair of blunt-pointed scissors curved
on the flat is more useful than a scalpel, and the handle of
the scalpel is of more service than the blade. The elevator
must not be vigorously thrust here and there, but must be
made to find an easy path. No tissue should be cut until
it has been well examined, and any especially resisting
structure must be exposed before it is torn across or cut.

A plexus of large, thin-walled veins will usually be
found covering the tumour. They must be separately
treated, and must be individually divided between two
ligatures. These vessels are easily torn across, and are very
apt to be adherent.

If the head be in the position of extension, the structures

on the front of the neck, and especially those over the face of the tumour, are apt to be stretched, and a vein so stretched may be quite unrecognisable. It is well, therefore, to have the head lifted now and then, so that the veins to be dealt with may be brought well into view.

Step by step the surgeon clears the whole of the front surface of the swelling, dealing with every bleeding point as it is met with, and not trusting either to the pressure of fingers or of sponges, or of artery forceps.

When the anterior surface is cleared, the next step is to approach the lateral margins of the growth, and to secure the thyroid vessels. It must be remembered that the thyroid body touches the carotid sheath. The position of that vessel should be made out as early as possible, and the utmost care taken to avoid it. If the bronchocele is in close contact with the main vessels, some special care may be required in separating the huge internal jugular vein from the capsule. The superior thyroid artery is then sought for at the upper extremity of the tumour. It may not be made out without some difficulty. If the vessels cannot be individually isolated, a double ligature may be passed by means of an aneurysm needle, and the vascular pedicle ligatured in two places and divided between. The vessels embraced by these ligatures may be separately sutured at a later period if thought necessary. The inferior thyroid artery is less easy to deal with. It is more deeply placed, has more numerous veins in relation with it, and is closely connected with the recurrent laryngeal nerve. No pains should be spared to expose it well. The ligatures should be applied at some distance from the lower border of the tumour, and the branches of the artery should be cut through just as they enter the bronchocele. In this way there is less danger of including the recurrent nerves.

The whole of the lateral border of the tumour is now separated. The same precautions are observed. The blunt elevator is the chief instrument. The scissors are used as required, and the vessels encountered are all ligatured and divided in the manner described.

The mass is turned over towards the opposite side, and

the posterior surface of the tumour cleared as far as the posterior median line.

The other lateral lobe is dealt with in precisely the same manner, and in due course the whole tumour is removed, *with care to leave some portion of the gland behind.*

The wound is now examined, and any remaining bleeding vessels are secured. No irritating antiseptic solutions should be used to the wound. The less it is rubbed with a sponge the better. The margins of the skin incisions are united with silkworm-gut sutures, which are not too closely applied. A drainage tube is rarely necessary, though a fine spiral one will do no harm.

The best dressing consists of a large pad of sterilised gauze and wool, the former being dry when applied. It is bandaged in position with as much pressure as it is considered safe to apply, by means of a light muslin bandage.

When the patient is placed in bed, the shoulders and head must be kept well raised, and the head may be fixed in the hollow of a loosely-filled sand-bag.

Partial Excision. — Excision of one-half of the thyroid, with division of the isthmus, is conducted in precisely the same manner as the above operation.

The incision is usually oblique, made along the anterior border of the sterno-mastoid muscle. The front of the bronchocele is cleared, and the superior thyroid artery secured.

After this vessel has been dealt with, the isthmus is severed. The fascia around it is divided, and the isthmus is then separated from the trachea by an elevator or director, and is well isolated. It may then be transfixed by a needle in a handle—such as is used in ovariotomy—and secured by a double set of ligatures, which are placed upon each side of the spot at which it is intended to divide it. It is treated somewhat like the ovarian pedicle. In cases of very large isthmus more ligatures may be called for. In some instances the isthmus may be more conveniently divided with a scalpel, and ligatures applied as required.

The tumour is now almost completely isolated, and the last step consists in ligaturing the inferior thyroid artery.

Enucleation.—When a goitre consists of a localised cyst or adenoma, it may be enucleated by peeling off the surrounding glands by means of an elevator. Care must be taken that the incision goes down into the actual wall of the tumour, and the size of the latter may often be diminished by tapping before it is shelled out. A formal ligature of the main thyroid vessels is not required, but all vessels going into the tumour should be secured with pressure forceps before division.

Mr. Berry recommends in these cases a transverse incision placed low down in the neck, as the resulting scar will be less conspicuous than a vertical or oblique one. The transverse incision, however, does not give so much room as the others.

The Question of Tracheotomy in these Operations.—If there be much dyspnœa in these cases of excision of the thyroid, the mass should be relieved from its tense surroundings as soon as possible, and the pressure removed from the trachea. Some assistance in this direction may be afforded by altering the position of the head, and by having the mass, as far as possible, withdrawn from the windpipe.

More immediate relief may be obtained probably by dividing the isthmus.

Tracheotomy is most emphatically to be avoided. The operation, if performed, would be carried out under the greatest difficulties, and the gravity of the whole procedure much increased.

CHAPTER III.

Excision of the Tongue.

Excision of the whole or of part of the tongue is carried out for the relief of many conditions. The great majority of the operations, however, are performed for malignant disease.

Extent of the Operation.—Small innocent growths of the tongue, or small portions of the organ, can be readily excised with the scalpel or with suitable scissors. If convenient, the edges of the ‚wound may be brought together with sutures. Sutures, however, are seldom necessary, and the wounds do well enough without them.

Cancer, in the great majority of cases, commences on the lateral aspect of the tongue. Whilst it is still confined to one side of the middle line there is no valid reason for removing the whole organ. Supposing it has infiltrated the anterior portion of both sides, the surgeon may often safely leave a stump formed of the posterior third or less. If the whole tongue be excised the floor of the mouth will ultimately project upwards and take its place to a surprising extent, but articulation is never so good as if a fair-sized stump has been left, and the constant flow of saliva may prove a nuisance to the patient. The general rule may be laid down to cut wide of the cancer, but leave any perfectly healthy part of the tongue. Recurrence is common in the lymphatic glands, rare in the stump of the tongue.

The particular lymphatic glands which are the dangerous ones with regard to cancer of the tongue may be defined with fair accuracy ; they are shown in Fig. 88.

There are one or two lymphatic glands placed in the

submaxillary triangle amongst the lobules of the salivary gland, but these are rarely involved in cancer of the tongue.
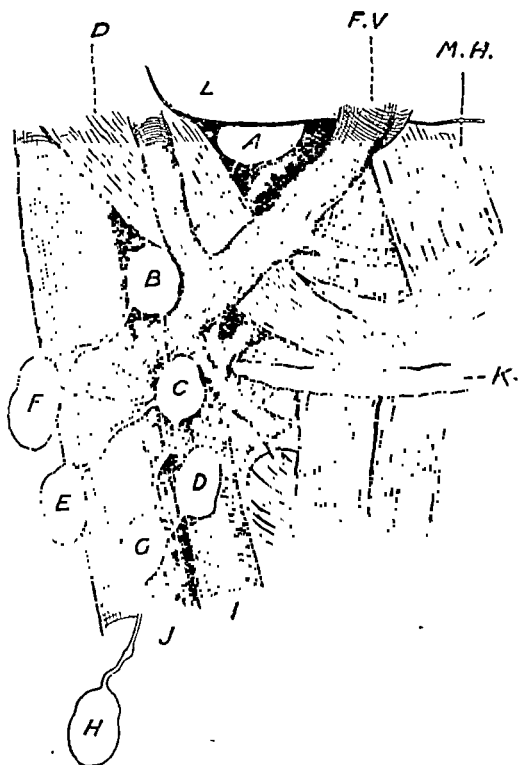
Fig. 88.—GLANDS OF THE NECK IN WHICH CANCEROUS DEPOSITS ARE LIKELY TO OCCUR.

L, Lower jaw ; *K*, hyoid bone ; *D*, digastric muscle ; *M. H*, mylo-hyoid ; *I*, common carotid artery ; *J*, internal jugular vein ; *F. V*, facial vein (the facial artery is seen beneath it). The submaxillary gland has been removed. The glands lettered *A* to *H* are those in which cancerous deposits are likely to occur. Of these *B, C, D, E, F*, and *G*, over the bifurcation of the carotid and on the jugular vein, are the most important.

Cancer of the lower lip, however, frequently infects them. If the primary growth in the tongue extends far back

K*

towards the tonsil, the gland marked A, situated under cover of the jaw, is liable to be infected.

But in the great majority of cases the carcinoma starts on the lateral aspect of the tongue, and deposits occur in the glands outside the submaxillary triangle at the junction of the facial and jugular veins, on the outer aspect of the carotid bifurcation, along the course of the main vessels and beneath the deep fascia (B, C, D, G, in Fig. 88). Later on, the glands at the back of the jugular vein (F, E), or even those lower down (H, etc.), become involved. As they soon adhere to the main vessels, their removal at a later stage becomes difficult and dangerous. Hence the operation for excision of cancer of the tongue should include at the same time a careful and thorough attempt at removal of the lymphatic glands referred to on one or even on both sides of the neck. This can be effected through a modification of the usual incision for ligature of the lingual artery, which is described later.

Should the Submaxillary Gland be Removed?—As already noted, cancerous deposits in this gland rarely accompany epithelioma of the tongue, though the submaxillary gland often is harder than normal owing to a degenerative sclerosis. Its removal complicates the operation to no great extent, but involves ligature of the facial artery and vein, and therefore prolongs the operation. If the primary growth encroaches on the floor of the mouth, it is certainly best to clear the submaxillary triangle, but the mylo-hyoid muscle should be left, to prevent the neck and mouth wounds from communicating.

EXCISION WITH PRELIMINARY LIGATURE OF THE LINGUAL ARTERIES, ETC.

Instruments Required. — Mouth gag. Curved needle in handle. Stout silk. Tongue forceps. Mouth retractor. Tenaculum. Blunt-pointed scissors, straight and curved. Volsella. Wells's pressure, dissecting, and fine-toothed forceps. Sponges in holders. Ligatures, etc.

Scalpels.   Retractors.   Blunt hooks.   Aneurysm needle.
Needles and sutures.

The instruments required for the first stage, including
ligature of the lingual and dissection of the glands, should
be in one dish, whilst those required for the second stage
—the actual excision of the tongue—should be kept in a
separate dish.

The best gag is Mason's or Hewitt's.   It must be
strong, and the blades be capable of wide separation.   The
" catch " fixing the gag when open must be secure.   A
" catch " is better than a screw.

The best cheek retractor is the broad rectangular re-
tractor used in nephrectomy operations.   It is in every
way excellent.

The scissors used for cutting out the tongue should be
quite straight, and quite flat and strong.   They should be
longer than the usual pattern, and should end in square
blunt points.   The cutting edge should extend up to the
very tip.

Position.—The patient lies close to the right-hand
side of the table.   The head and shoulders are well raised,
and the arms are folded behind the back.   The surgeon
stands to the right and the chief assistant to the left.   The
anæsthetist stands at the head of the table, and by him an
assistant who holds the gag and steadies the head.   The
gag is introduced on the left side of the mouth, is very
firmly held, and, with a Mason's gag, it is a good rule to
keep the handle of the gag always against the patient's ear.
A good light is essential.

The Operation.—In many cases it is necessary to
tie both lingual arteries.   The surgeon commences on the
side on which the cancerous growth is situated, and that on
which the lymphatic glands will therefore require to be dis-
sected out.

During the first stage the gag is not introduced, but it
is often convenient to introduce a loop of silk ligature
through the middle of the tongue, so that in case the
breathing should become embarrassed traction can be made
on it.

The patient's head is turned on the side, and kept steadily in this position with the chin raised.

A curved incision is then made from just below the angle of the jaw towards the symphysis; it extends downwards towards the hyoid bone (Fig. 89).

Fig. 89.—INCISIONS FOR LIGATURE OF THE RIGHT LINGUAL ARTERY WITH REMOVAL OF LYMPHATIC GLANDS.

The sterno-mastoid muscle, the hyoid bone and its depressor muscles, are indicated.

A second, nearly vertical, cut is made along the anterior edge of the sterno-mastoid muscle for three inches.

Both incisions are made through skin and platysma muscles, and then more deeply through the fascia.

If it is not proposed to remove the submaxillary gland, the lower edge of the latter is thoroughly exposed, and the whole gland raised upwards with its coverings. This may

be done by means of a broad retractor. The external flap
is now carefully dissected back and held by a suture re-
tractor. The bifurcation of the carotid artery, and the
internal jugular vein lying behind and somewhat over-
lapping the carotid, are exposed, and all lymphatic glands
that can be discovered in this region are cautiously dissected
out (see Fig. 88). This is the most tedious part of the
operation, but at the same time the most important. The
submaxillary gland being well raised, the tendon of the
digastric muscle is drawn downwards with a blunt hook.
The posterior edge of the mylo-hyoid is now defined, and
the hypoglossal nerve with the ranine vein are seen passing
beneath it.

With blunt dissection the nerve and vein are displaced
slightly upwards, particular care being taken not to wound
the vein. In the small triangle formed by the nerve, the
posterior belly of the digastric, and the posterior border of
the mylo-hyoid, the surgeon now incises the hyo-glossus
fibres which form its floor. This is done cautiously, the
muscle fibres being fixed by fine-toothed forceps. It is easy
to go too deeply and wound the lingual artery, or perhaps to
miss it and work in too deep a plane. As a rule, provided
that the points mentioned are carefully observed, the artery
is found with ease. An aneurysm needle is passed from
below round the artery, and the latter securely tied. The
submaxillary gland is then replaced, all bleeding points are
secured by catgut ligatures, and the wound is quickly sewn
up with silkworm gut. It is usually best to leave a small
drainage-tube in the lower angle of the wound.

Supposing that the epithelioma is wholly marginal, and
there is no need to remove more than half of the tongue,
the operator now proceeds to deal with the latter, after
securing an aseptic dressing on the neck wound. In some
cases, however, it will not be safe to limit the excision to
one half the tongue. The patient's head is then turned to
the opposite side, and the other lingual secured.

A temporary dressing has been secured around the neck,
the instruments previously required are put aside, and the
anæsthetist arranges to give chloroform through Junker's

inhaler with a metal tube (or by means of Hewitt's gag).

The operator stands on the right side of the patient, the gag being inserted on the left. The assistant must be provided with plenty of small pieces of sponge mounted in holders, and the position of the gag must be carefully supervised—otherwise it is apt to slip forward. The instruments must be placed within easy reach of the operator, who will usually find it convenient to stand on a stool, so that he can look down into the back of the patient's throat. When the gag is opened it often happens that the breathing becomes obstructed and the patient somewhat cyanosed : this condition should be relieved by traction on the tongue, made with the ligature and by holding the jaw forwards.

With vulsellum forceps in the left hand and scissors in the right, the operator now excises the affected area of tongue. He must divide the mucous membrane at a considerable distance from the edge of the epithelioma, and continue the incision so that a large margin of healthy tongue is removed with the growth. Sometimes it is necessary to remove the entire organ, in other cases only one half; in some a wedge-shaped piece is removed. The bleeding, provided the lingual arteries have been properly secured, is mainly venous and insignificant in amount. Wells's forceps should be applied, in case any vessel spurts. By turning the patient's head to one side, and by careful sponging, the blood should be entirely prevented from running down the throat.

Until the patient comes round from the anæsthetic, he should be kept lying somewhat on the side, and a nurse should use a mounted sponge from time to time in the mouth. When he has come round the head and shoulders should be well supported by pillows, as venous oozing will be diminished by this means.

Comment.—If the submaxillary gland be removed, the preliminary stage requires to be slightly modified. The platysma and fascia are dissected off the gland and held upwards; the facial vein and artery are exposed at the lower and posterior corner of the gland. Both vein and artery

are ligatured and divided. The gland, with one or two contained ·lymphatic ·glands, is then dissected out and drawn forwards, the facial vessels being again secured as they pass over the jaw. The prolongation of ·the gland along Wharton's duct is drawn out from beneath the mylo-hyoid muscle, and a ligature should be put round the duct before it is divided (to prevent possible, contamination of the wound by backward flow of saliva). A lymphatic gland lying under the angle of the jaw (*see* A, Fig. 88) should be removed at the same time.

Whenever the submaxillary gland is removed, a drain should be left for a day or two ; otherwise blood collects in the space. Before sewing up the wound the surgeon should make certain that his ligatures on the divided facial vessels are holding well.

The method described above combines the advantages of preliminary ligature of the lingual arteries with excision of the lymphatic glands most likely to be involved by epitheliomatous deposit.

CHAPTER IV.

Œsophagotomy.

THE operation of œsophagotomy is carried out, as a rule, for the removal of foreign bodies which have become impacted in the tube. In one or two instances attempts have been made to dilate a simple stricture of the gullet through an incision in the neck.

Instruments required. — Gag ; tongue forceps ; œsophageal bougie and forceps ; scalpels ; blunt-pointed bistoury ; retractors ; sharp hook ; artery and pressure forceps ; dissecting forceps ; long bladed, toothed dissecting forceps ; scissors ; needles ; needle-holder ; periosteal elevator to assist in removing the foreign body.

The Operation.—The general features of the operation are similar to those which attend a ligature of the common carotid. The gullet is approached from the *left* side of the neck, inasmuch as the tube inclines to that side. Should the foreign body be felt more distinctly upon the right side, then the incision may be made in that quarter.

The shoulders are well raised, the head is a little extended and is turned to the right or opposite side.

Every attempt should have been made to define the exact position of the foreign body before the incision is begun. A skiagram of the neck showing the foreign body is indispensable. The situation of the cut will be influenced by the locality of the foreign body. Very usually it is the commencement of the œsophagus that is exposed.

The skin incision will commence opposite to the upper border of the thyroid cartilage, and will be continued downwards along the anterior border of the sterno-mastoid muscle for about three inches.

The first steps of the operation are identical with those for ligaturing the common carotid.

As soon as the skin and fascia have been divided, the finger should be introduced into the wound, and the position of the impacted substance be further defined.

The omo-hyoid muscle is drawn downwards, and must be divided if necessary. The sterno-hyoid and sterno-thyroid muscles must be drawn a little aside, and, in cases where the foreign body is low down, may need to undergo some division of their fibres.

The sterno-mastoid and the large vessels are drawn outwards. The carotid sheath is not disturbed.

The trachea and larynx are drawn over, or rather tilted over, to the inner or opposite side.

The position of the gullet can now be readily made out.

It may be desirable at this stage to pass a bougie or a pair of œsophageal forceps, in order to accurately demonstrate the situation of the tube and of the impacted body. It must be remembered that the œsophagus, when empty, is flat and tape-like, and does not exist as the well-rounded tube which figures in most anatomical text-books.

The inferior thyroid artery and the superior and middle thyroid veins must be carefully avoided. The last-named vessels will usually need to be ligatured and divided.

All bleeding having been arrested, the gullet is steadied by a pair of fine, long-bladed, toothed forceps, and is opened longitudinally over the site of the foreign body.

The recurrent laryngeal nerve runs in the groove between the œsophagus and the trachea. The gullet must be opened through its lateral wall, so as to avoid injury to this nerve. In the actual operation it will appear that the œsophagus is being opened as far back as possible.

The opening in the tube must not be extended by tearing, or be dilated with dressing-forceps; it must be cautiously enlarged by a blunt-pointed bistoury.

The removal of the foreign body must be carried out with the greatest care, and a curved periosteal elevator will be found a most valuable instrument in freeing the substance and prising it into the wound.

When the body is of irregular shape, and has been long impacted, very great difficulty may be experienced in removing it. I was occupied in one case for more than twenty minutes in extracting from the gullet a hard-metal plate of teeth, which had been impacted for eleven months.

By the introduction of forceps through the wound, foreign bodies have been extracted from the thoracic segment of the œsophagus.

If the wound in the gullet be a clean cut, if the case be recent, and the foreign body have been impacted for but a short space of time, then the œsophagus incision should be closed; and this more especially applies to the cases of children and young subjects. The sutures employed should be of very fine catgut, and they can be most conveniently introduced by means of a curved needle, held in a Hagedorn's holder.

If, however, the body has been long impacted and the gullet is much ulcerated, or if the wound in the gullet has been lacerated, and has been exposed to much bruising, then the use of deep sutures had better be dispensed with. The skin-wound in such case may be narrowed above and below by a few suture points, but the median and main part of the wound must be left open. A good-sized drainage-tube should be passed to the bottom of the wound. In no case is it well to entirely close the superficial wound, even in instances where the incision in the œsophagus has been united. The wound in the gullet may yield, or may be torn open by violent vomiting, and the food-matters and mucus which find their way into the tissues of the neck should be permitted the very freest means of escape.

If in a case where the gullet wound has been closed no sign of extravasation occur for seven days or so after the operation, then the superficial wound may safely be closed.

An open wound is the great safeguard after œsophagotomy.

Part VIII.

OPERATIONS ON THE ABDOMEN.

CHAPTER I.

ABDOMINAL SECTION.

THE term abdominal section is applied to the opening of the abdominal cavity either for purposes of exploration or with the object of operating upon the abdominal or pelvic viscera.

Instruments Required.—Two stout scalpels, with a cutting edge of 1½ to 2 inches in length. Dissecting forceps (2 pairs). Straight probe-pointed bistoury. Pressure forceps (10 or more pairs). Large pressure forceps (2 or 3 pairs). Medium-sized pressure forceps. Artery forceps. Hagedorn's needles for the parietal sutures. Needle holders. Small needles (curved and straight). Two large blunt hooks. Scissors (straight and curved on the flat). Catgut and silk in various sizes. Silkworm-gut. Sponges. Sponge-holders.

To these may be added—dishes for instruments, macintosh sheets, the dressings and binder, an electric lamp or an ordinary lamp, and hand mirror.

1. **The Parietal Incision.**—The surgeon steadies the abdomen with the left hand, the thumb being on one side of the intended wound and the fingers on the other, and makes a clean cut in the median line from two to three inches in length.

The incision is usually placed midway between the umbilicus and the pubes, and stops some two inches above the pubes. In fat subjects the incision will have to be a

little longer. The knife should make a clean cut through the skin and subcutaneous tissues down to the aponeurosis. Bleeding is checked by pressure forceps, which are left *in situ.* The bleeding vessels must be neatly isolated and neatly picked up. A casual mass of subcutaneous fat must not be clutched up with the vessel between the blades of the forceps. The operator need not trouble about the sheath of the rectus. There is no linea alba below the umbilicus, and the knife need only follow the median line, avoiding the cutting of muscle as far as possible. Unless the two recti are separated by distension, one or both of the rectus sheaths will as a rule be opened.

The transversalis fascia is now reached. It is possible to mistake it for the peritoneum, and the subperitoneal fat beyond for omentum. This fascia and the fat, if any, beneath should be divided by a clean cut of the knife. No director is required, nor should one be used. It is about this stage of the operation that some surgeons enlarge the area of the wound with the fingers, tearing up the fascia in a meaningless manner. All such handling of the wound is useless, and distinctly to be avoided. The advice that the peritoneum should be exposed by tearing is not sound.

It is important to clearly recognise the peritoneum. It is best identified by noting the tissues that have been cut through. The "blue colour," the "glistening surface," and the "arborescent vessels" belong to the department of fiction.

When adhesions exist, the peritoneum may not be demonstrable as a coherent membrane.

Before any attempt is made to open the abdominal cavity all bleeding should have been checked. Any pressure forceps that are attached need not be removed at the present stage. The peritoneum should be pinched up as a very minute fold with a good pair of dissecting forceps. Normal peritoneum can be so picked up. Thickened and adherent peritoneum cannot be thus dealt with, nor can the wall of the bowel be quite so readily and minutely picked up should a piece of gut be exposed and its surface be mistaken for the lining membrane. The forceps that grasp the little fold of peritoneum should be moved to and fro and lifted up and

down, to ascertain whether the membrane is free or not. The membrane is finally divided by cutting upon or close to the point of the forceps, while they are being drawn away or lifted up. No hook or other unusual instrument is required to pick up the peritoneum, but toothed forceps are often useful.

When adhesions exist, there is difficulty in ascertaining when the abdominal cavity has been really reached, and there is nothing to guide the operator but his surgical and anatomical intelligence. Any doubtful layer of tissue should be picked up and gently rolled between the finger and thumb. Its character can in this way be at once estimated, and the existence of deeper attachments demonstrated. The operator who has the fear of adhesions before his eyes, and who has not noted the layers of tissues as they have been cut, may readily separate and strip off the undivided peritoneum with his fingers, under the impression that he is dealing with adhesions within the abdominal cavity. This is especially apt to occur when a large smooth tumour is pressed against the parietes.

The peritoneum should be divided by a clean even cut. It may conveniently be divided by scissors if preferred. I have seen the membrane rent open with the fingers—a practice that has nothing to commend it.

As soon as the abdomen is opened, the divided peritoneum on either side of the centre of the wound is seized with pressure forceps. These forceps remain in place until the operation is completed. They act as retractors ; they keep the peritoneum in position, and they render the introduction of the finger or of a sponge very easy. They also serve as a guide to the introduction of the sutures. Before they are dispensed with the little margin of peritoneum which they have hold of should be cut away with the forceps, since this tissue is likely to be damaged by long compression. When the forceps are in position, two fingers can be introduced for purposes of exploration.

If the incision has to be enlarged, it is effected with a straight probe-pointed bistoury, the two fingers being used as a grooved director. If the wound be extended down-

ward, the position of the bladder must be defined before the knife is used.

If the hand has to be introduced, the incision must of necessity be increased. There is often a disposition not to make the wound large enough. More harm may be done by rough efforts to drag a solid growth through a small incision than by a liberal extension of the incision in the median line.

In certain cases, as soon as the wound has been completed, a large sponge may be at once introduced into the pelvis. It is retained there during the operation, and, by absorbing any blood that finds its way into Douglas's pouch, saves sponging at a later stage. The intestines must be prevented from protruding, either by the introduction of a flat artificial sponge or by the fingers of an assistant. One of those present should be entrusted with the responsibility of taking count of all sponges introduced into the abdomen.

The omentum often gives much trouble, especially the fine thin omentum of young children, by clinging to the fingers and to sponges, and by becoming entangled with instruments. It may be necessary to keep it out of the way by means of a long narrow sponge attached to slender forceps.

2. **Treatment of Adhesions.**—Adhesions must be dealt with according to common surgical principles. The lighter, more recent, and more slender can be broken down by the finger or by a sponge.

The firmer must be clamped, divided, and tied—either with catgut or fine silk. Extensive strands of adhesions should be clamped in sections, cut, and the bleeding points picked up individually with artery forceps, and tied in the usual way.

In no circumstances is the use of the actual cautery to be commended for the arrest of bleeding from divided adhesions.

Oozing from a level surface can very easily be checked by continued pressure with a sponge. If the oozing be persistent, and if no individual vessels can be isolated and tied, the bleeding surface when small may often be

" sequestrated " or sewn over. A Lembert's suture is made
to traverse the peritoneum on either side of the bleeding
area, and when the suture is drawn tight the bleeding
surface is covered over.   When the area is large a fine
needle, carrying silk, is made to pass beneath the bleeding
surface, and when this buried suture is drawn tight the
surface is constricted and turned in.   This may be called
" sewing in " as compared with " sewing over," when
peritoneum is employed.   Great care should be taken in
dealing with deep pelvic adhesions.   They can be exposed
by the use of ivory spatulæ, and in demonstrating their
character and attachments reflected light from a mirror or
the electric lamp is very useful.

Adhesions to the bowel and to the bladder must be
gently dealt with. When slender, they can be readily
stripped off by means of a sponge. When dense and ex-
tensive, it is better to clamp the adhesion, to cut it
through at some little distance from the viscus, and to
ligature it *in situ*. In separating adhesions from bowel, it
is easy to tear away the serous coat and to expose or even
tear the muscular coat. Such false membranes are probably
nourished from the viscus to which they are attached, and
I have seen no harm to follow from leaving quite consider-
able masses of such tissue attached to intestine. In cases
where a portion of cyst wall is firmly attached to the bowel,
it is very undesirable to make persistent attempts to separate
the two.   It is far better to cut away the cyst, leaving the
adherent portion still attached to the bowel.   Such attached
portion may be reduced to the smallest dimensions, by dis-
secting off as many laminæ as possible, and be allowed to
remain as a permanent appendage to the gut. In many cases
I have left a considerable portion of the cyst wall still
attached to the bowel.

It should be borne in mind that, in endeavouring to free
the intestine of firm adhesions, it is very much easier to
tear the bowel than to tear the false membrane.

Moreover, such attempted separations, even when they
do not tear the gut, are apt to strip off a great deal of its
peritoneal coat.   The muscular coat beneath is probably

atrophied from disuse, the result of the adhesion, and a perforation of such damaged intestine is quite possible. Extensively adherent intestine will be found to have very attenuated walls, and to be most readily torn.

Adherent omentum can be dealt with in considerable sections. The adhesions may be peeled off with the finger. Portions, of the thickness of the forefinger, may be included in one ligature. It is more satisfactory, however, in dealing with omentum, to ligature the individual vessels with silk whenever practicable. The method adopted must depend upon the vascularity of the tissue. In some cases, where much traction has been exercised upon the epiploon, its cut surface will scarcely bleed at all. On the other hand, when an ovarian cyst, with a twisted pedicle, is obtaining its chief or sole blood supply from omental adhesions, the vascularity of the tissue is often considerable.

Adhesions may in some cases be so dense, so close, and so extensive that they have to be divided by the scalpel by extensive incisions. It must be borne in mind, however, that such adhesions have sometimes but a slight vascularity, and that they can be often divided without remarkable bleeding. Indeed, I have observed that the hæmorrhage from a surface exposed by such division is usually not so considerable as that from the area exposed by tearing down soft recent adhesions with the finger. Still, these dense attachments must always be regarded with the greatest respect.

In many instances when an organ, such as a cyst or a diseased vermiform appendix, is so very adherent as to be described as buried or lost in adhesions, it is well to ignore at first the actual adhesions and to divide the peritoneum at some little distance from the adherent organ, so as to open the subserous tissue. The finger is introduced into this lax tissue, and the separation of the organ is carried out subperitoneally, the adhesions being divided upon the finger (introduced beneath them) as soon as they are well isolated.

Whenever practicable, it is desirable that a very adherent structure should be first of all approached by the subperitoneal route. When no inflammatory adhesions exist, but when the tumour or cyst has, in enlarging, made

its way beneath the peritoneum so as to become more or less entirely hidden, then the separation of the mass should always be effected by dividing the peritoneum around it, and by enucleating it through the medium of the subperitoneal tissue. In such a proceeding care must be taken to note the position of the normal blood vessels of the part concerned. These are secured as they are met with.

3. Toilet of the Peritoneum in Septic Cases.— In an abdominal operation in which no septic material is encountered—and the majority of abdominal sections are of this type—the peritoneum needs very little if any attention. The serous membrane is very well able to look after itself, and the more one sees of abdominal operations, the more one is impressed with the marvellous powers of the peritoneum in this direction.

It is well that any effusion, such as blood or cyst fluid, should be removed, but that object is never to be persisted in at the cost of extensive sponging.

In cases where there has been an extensive extravasation of septic fluid, it will be necessary to wash out the peritoneal cavity. For this purpose it is best to use plain water which has been sterilised by boiling, and which is kept about the temperature of the blood (100° F.). Care should be taken that this temperature is not exceeded, and every operating theatre should be provided with apparatus for aseptic irrigation.

In cases where peritonitis exists, or where fæcal matter has escaped into the abdominal cavity, or where the extravasation consists of glairy cyst fluid, or of pus, or where much colloid or semi-solid matter has escaped, thorough flushing out of the abdominal cavity with warm water is alone efficacious.

As soon as the fluid poured in comes out clear, what remains may be taken up with a sponge.

On completing the intra-abdominal operation, great care should be taken to ensure that no sponge or instrument has been left in the depth of the cavity.

4. Closure of the Abdominal Wound.—In sewing up the incision made through the abdominal wall, the

surgeon should aim at leaving the parts as far as possible in their original condition, *i.e.* the peritoneal surface should be smooth, and the scar in the muscular and aponeurotic layers firm and unyielding. Thus the possible dangers of adhesions of intestine, omentum, etc., and of ventral hernia will be avoided. Further, if any buried sutures are employed they must be absolutely aseptic; otherwise they are apt to cause troublesome sinuses, which will only heal on the expulsion of the sutures.

In many parts of the abdomen, such as the linea alba, a good plan is to pass silkworm gut stitches through skin, aponeuroses, muscle, and peritoneum. These sutures are securely knotted, and should be left in a full fortnight. A more perfect peritoneal surface can, however, be obtained by first suturing the two cut edges of this layer (these edges are secured by the pressure forceps, which were applied when the wound was made). A continuous suture line of fine catgut, introduced on a curved needle, is the most convenient. This detail, which takes only a minute or two, is strongly recommended in the majority of cases; besides preventing adhesions of intestine, etc., in the future, it is a convenience during the rest of the suturing, as the peritoneal cavity is thus shut off. A series of silkworm gut sutures is then passed through the remaining layers.

If the abdominal incision be extensive, a thin flat sponge of greater length than the parietal wound is placed upon the intestines under the opening. It is retained during the introduction of the sutures. It serves to protect the intestines, and to absorb such blood as oozes from the suture points before the sutures are tied. If the thread be too small and the parietes thick, the suture has a tendency to cut through the tissues. If it be too large, it acts as a species of seton. Large-sized threads of silkworm gut appear to be peculiarly well adapted for these wounds. They merely require care in tying, and a certain number should be tied in a double knot, so as to avoid the risk of giving way when the patient strains or vomits.

Curved needles, three inches in length, should be used. The needles must be passed through the whole thickness of

the parietes, and it is especially important that they should include the peritoneum. They are most conveniently introduced in the following manner :—

A blunt hook is inserted into either extremity or angle of the incision, and by exercising traction upon the hooks in opposite directions (precisely in the median line) the edges of the wound are rendered straight and parallel to one another. The incision opening can be made, in fact, a mere chink. By the use of the hooks the most perfect adaptation of the edges of the wound is ensured. If the abdomen be distended, the narrowing of the incision opening tends to prevent protrusion of the intestines. If the belly wall be flaccid, the hooks enable the assistant to make the skin tense, and at the same time to draw the part of the parietes about to be sutured away from the viscera, and thus render a wound of the latter less easy.

The sutures should be introduced close to the margin of the wound, and at intervals of half to three-quarters of an inch from one another.

No suture should be tied until all the threads have been introduced, and until it is seen by traction upon the threads that a perfect adjustment of the edges can be effected.

The sutures should be tied in order from above downwards, traction being maintained all the while upon the blunt hooks. Care should be taken that the suture, as it is being tied, does not pick up and include a shred of the omentum. The peritoneal surface of the wound should be carefully examined with the finger from time to time. Before the last two, or possibly three, sutures are tied, the flat sponge should be seized with a pair of large pressure forceps and carefully dragged out, the blunt hooks being relaxed the while. Omentum is more apt to be included in the last sutures tied than in any others. The hooks are not removed until all the deep sutures have been secured.

Superficial sutures may now be introduced at any spot along the wound where the skin still gapes between the deep suture points. These are best introduced by a curved needle of medium size held in a suitable needle-holder.

CHAPTER II.

OVARIOTOMY.

Instruments Required.—The following special instruments are required, in addition to those already enumerated as needed for the operation of abdominal section.

Ovariotomy trocar and cannula with tubing, Nélaton's volsella (two pairs), plain volsella, pedicle needle, simple trocar.

1. **The Incision.**—The abdomen is opened after the manner already described. The incision should be of such a length as to enable the surgeon to extract the tumour with ease. About three inches is the average length of the skin incision when first made. It may be commenced about three inches below the umbilicus.

2. **Exposure and Examination of the Cyst.**—The cyst is exposed, and is recognised by its white shining surface when free. Occasionally the peritoneum is found to be much thickened, or to be adherent to the cyst wall. In attempting to demonstrate the cyst under the latter condition, it should be remembered that to cut prematurely into the cyst is less serious than to strip the peritoneum from the parietes, under the impression that it is the wall of the cyst.

If any ascitic fluid be discovered, it should be allowed to escape, and should be pressed out of the flanks by the assistant. As soon as the peritoneal cavity is opened, a ruptured ovarian cyst may be discovered. The effused matter can be best got rid of by irrigation with warm sterilised water, at blood heat, and continuing the washing until the fluid flows out clear.

At the earliest possible opportunity the position and state of the uterus should be made out.

The possibility of pregnancy in cases of supposed ovarian disease should never be lost sight of.

It is possible also that the reputed ovarian tumour may be uterine.

3. **Demonstration of Adhesions.**—Assuming the case to be a straightforward one of ovarian cyst, the tumour should be allowed to project into the wound.

The fingers or hand may be passed round the cyst to ascertain if any adhesions exist, and to estimate their character.

During such examination the lighter forms of adhesion may readily be broken down as the fingers pass gently over the surface of the growth. If firmer adhesions are found to exist, they must be fully demonstrated. Adhesions of all kinds are more readily to be dealt with before the tumour has been emptied by tapping. By attempting to break down adhesions after the cyst has been emptied, a portion of adherent bowel may be torn, the flaccid cyst wall and the bowel being difficult to distinguish from one another.

4. **Tapping of the Cyst.**—Before actually introducing the trocar, a sponge may be inserted between the cyst wall and the lower angle of the incision, in order to absorb any fluid which may escape.

The cyst is steadied by the surgeon's left hand while the trocar is driven into its wall. In order to bring the walls well up to the hooks on the trocar, the plain volsella may be used; or the assistant may drag the cyst wall up within the grasp of the hooks as the tumour becomes more flaccid. The volsella is apt to make holes in the cyst, through which fluid may escape. Traction upon the cyst should never be made through the hooks on the trocar alone. These hooks are more for the purpose of holding the cyst wall against the cannula. "After the first cavity has been emptied, a second, a third, and more, if necessary, may be tapped successively, without removing the cannula from its hold, merely by pushing the trocar forward and

thrusting it through the septum which separates the emptied from the adjacent full cavity. In this manner the whole tumour may be emptied of its fluid contents, and its bulk so reduced that it may be drawn through the abdominal opening without undue force " (Sir Spencer Wells).

If the cyst be of moderate size or small it may be removed entire without tapping. This implies a larger abdominal incision, but the tumour remains firm and distinct, and is readily handled.

5. **Removal of the Cyst.**—As soon as the part of the cyst that has been pierced by the trocar is well free of the abdominal cavity, the cyst wall may be grasped by two Nélaton's volsellæ, and traction upon the main body of the tumour made by means of these instruments. At this time also the sponge introduced at the lower angle of the incision may be removed.

As the cyst is drawn outside the abdomen, the chief assistant follows it, as it were, from above.

By means of two large sponges—one held in each hand —he keeps the edges of the upper part of the wound together, exercises gentle pressure upon the escaping cyst, and prevents the protrusion of any coil of intestine or of the omentum. If the tumour be still of large size, any remaining secondary cysts may be tapped with a common trocar, or the supporting septa may be broken down with the fingers. When the secondary cysts are small and numerous, and the mass feels semi-solid, or when abundant glandular growths exist, the substance of the tumour may be broken up by the hand. To effect this the trocar puncture must be enlarged, and, the edges of the opening having been grasped by Nélaton's volsella, the hand can be introduced. Care must be taken that the forceps are so held that none of the broken-down contents can find their way into the abdominal cavity.

In manipulating the cyst, and especially when freeing it from adhesions, it is possible to tear the cyst wall and to allow the cyst contents to escape into the peritoneal cavity. The accident is not a serious one, as the fluid is nearly always quite sterile. If the rent be small, it may

be closed by being grasped with *large pressure forceps;* if larger, an attempt should be made to bring the opening without the abdominal wound, and, by means of wedging sponges around the tear, to conduct the escaping fluid out of the belly.

In this way the injured cyst may be entirely emptied, and little of the fluid have found its way into the serous cavity.

In the case of more solid tumours the abdominal incision
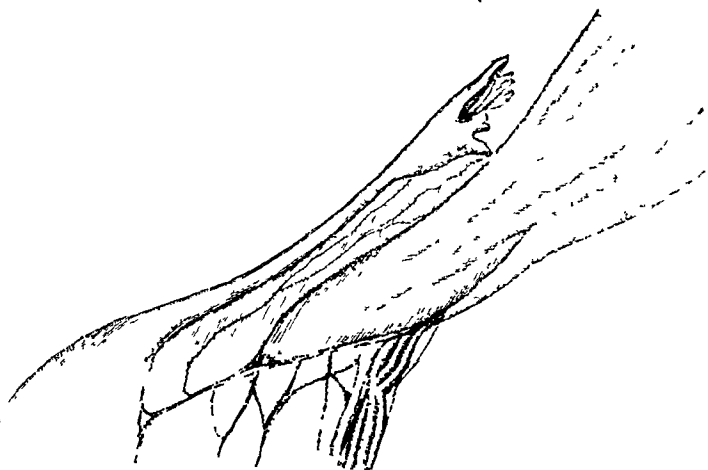
Fig. 90.—PEDICLE OF AN OVARIAN CYST.

The cyst has been tapped   The vessels in the outer border of the pedicle are indicated (semi-diagrammatic).   (*Doran.*)

must be enlarged.   It is much less serious to increase the size of the wound than to run the risk of rupturing the tumour by endeavouring to drag it through too small an opening.   In these cases there is no virtue in a small incision.   The escape of solid tumours is much assisted by judicious lateral pressure upon the abdomen, exercised by the hands of the assistants.

6. **Treatment of Adhesions.** — This matter has already been dealt with (page 310).

7. Treatment of the Pedicle.—The cyst having been drawn without the abdomen, nothing remains but to deal with the pedicle, which, in an uncomplicated case, now occupies the lower angle of the incision. In the majority of cases the pedicle is long, free, and tolerably broad. It is easily recognised by the Fallopian tube, which marks its upper or inner border (Fig. 90).

The pedicle is secured by ligatures. The best material for the ligature is silk. Many surgeons use and strongly recommend kangaroo tendon. If silk be used it should be no thicker than is consistent with sufficient strength not to break in tying the knots.

In dealing with the pedicle, a rule should be observed which should apply to every abdominal operation—*a ligature should never be so applied as to include undivided peritoneum.* Exceptions to this important rule are very few, and are represented by such measures as the ligaturing of omentum and the securing of certain adhesions.

Before any ligature is applied, the peritoneum should be divided. The procedure is well illustrated by the treatment of the ovarian pedicle. The pedicle is as well displayed as is possible, and then with a small scalpel the serous membrane is divided completely on both sides of the pedicle in the line the ligature will follow. The subserous connective tissue in the pedicle is thus displayed, and gaps in the membrane are made evident, or are capable of being made evident. By enlarging these gaps the individual factors of the pedicle are isolated, the pedicle is reduced in bulk, and the separate parts are ligatured cleanly and precisely. A pedicle needle is not needed, as the ligatures are passed through the gaps made. I use three ligatures, one for the Fallopian tube, one for the ovarian ligament and tissues about it, and one for the pampiniform plexus and artery. These ligatures will not slip, whereas ligatures which embrace undivided peritoneum will often slip. The division of the peritoneum, moreover, undoubtedly saves much after-pain.

The knot tied should be a double reef or surgeon's knot, and the threads should be drawn as tightly as possible.

It is important, as the ligatures are tightened, that the assistant should relax his traction so that there is no tension of the pedicle.

The exact point at which the pedicle is transfixed must be determined by surgical common sense. The ligatures should not be placed quite close to the uterus on the one hand, nor too near the cyst on the other.

The threads must be cut short, and the pedicle divided with scissors three-quarters of an inch beyond the line of the ligatures.

Before the stump of the pedicle is dropped back into the pelvis, forceps may be attached to either margin of it, so that at any time before the completion of the operation the divided surface may be drawn up for inspection.

There is nothing to commend the practice of clamping the pedicle before the ligatures are applied.

In examples of very broad pedicle the tissues may have to be ligatured in more than three sections.

8. **Completion of the Operation.**—All bleeding having been arrested, the opposite ovary may be reached by passing the fingers along the uterus, and may be drawn up and examined.

The pelvis is now well sponged out. The stump of the pedicle should be drawn up by means of the forceps still attached to it, and, it having been examined, the instruments may be removed. Sponges should be counted, and the greatest care taken that no sponge or instrument has been left within the abdominal cavity.

No drainage will be required. Nothing now remains but to close the abdominal wound after the method described in the previous chapter.

CHAPTER III.

REMOVAL OF THE UTERINE APPENDAGES.

THE removal of the uterine appendages in cases where the structures are anatomically normal, or practically so, is an exceedingly simple procedure.

When, however, the appendages are diseased, the surgeon who proposes to remove them embarks upon an enterprise the precise course and ending of which he cannot foretell. Some of these operations are difficult and complicated, and present a very uncertain and intricate series of conditions.

The operation will be described as it would be carried out in a case in which the parts are practically normal.

Instruments required.—The same as for ovariotomy with the exception of the trocar, the volsella, and the cyst forceps.

The Operation.—The patient having been prepared for abdominal section, a vertical incision about two inches in length is made over the linea alba below the umbilicus. The centre of the cut will be nearer to the symphysis than to the umbilicus.

The cavity of the peritoneum is opened in the manner already described. The intestines and great omentum will be largely prevented from getting in the operator's way if the patient has been placed in Trendelenburg's position— *i.e.* with the pelvis raised above the level of the thorax.

All bleeding having been checked, two fingers are introduced into the wound, and the fundus uteri is sought for. The fingers embrace the broad ligament as if they were the blades of very long dressing forceps, and are carried outwards—one on each side of the tube—until they are arrested by the ovary.

The ovary is now drawn out of the abdomen by the two fingers, which retain the same forceps-blade attitude. It is then handed over to an assistant, who holds it well away from the abdominal wall. The surgeon displays the pedicle, carefully and completely divides the peritoneum with a fine knife, and ligatures the structures exposed in the manner already described. Three silk ligatures are employed, one for the tube, one for the vessels, and one for the ovarian ligaments and remaining structures.

It often happens, even when no adhesions exist, that there is some difficulty in dragging the ovary well out of the wound. This is notably so when there is a thick layer of fat upon the abdominal parietes. In such cases much strain falls upon the broad ligament, and the surgeon's fingers alone are not sufficient to hold the parts in place. In these instances it is necessary that the appendages should be seized by large-elbowed pressure-forceps.

The pedicle in this operation is secured in precisely the same way as in ovariotomy (page 320). Silk of medium thickness is commonly used, but kangaroo tendon answers admirably.

The parts are cut away close to the retaining fingers or the retaining forceps, and at least a third of an inch from the ligature.

Before the division is made, it is well to fix one or possibly two pairs of artery forceps upon that part of the pedicle which lies between the ligature and the intended line of section. When the division is made, the forceps— which inflict no damage upon the part—prevent the stump from falling at once back into the pelvis, and allow it to be examined at leisure, and to be drawn forth should further ligature be needed.

The wound is closed, and is dressed in the usual way.

CHAPTER IV.

METHODS OF UNITING INTESTINE.

THE methods devised have been not only very numerous, but also very varied.

It is possible, however, to arrange the greater number
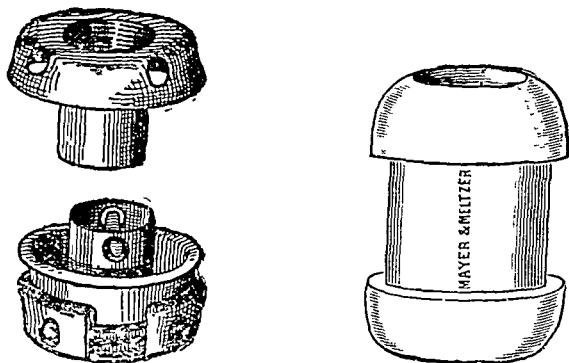
Fig. 91.—MURPHY'S BUTTON· AND ROBSON'S BOBBIN.

The left-hand figure shows the small size of Murphy's Button suitable for use in the small intestine. The right-hand figure shows Robson's decalcified bone bobbin.

of the procedures that have been devised under the following divisions :—

Methods.— 1. The divided bowel is brought into the abdominal wound and is retained there. No immediate attempt is made to close the breach in the intestine. An artificial anus is of necessity established. The closure of this fæcal fistula is left to a subsequent period.

· 2. The two halves of a Murphy's button are secured by suture in each end of the divided intestine, and are then

fitted together. Sometimes a few additional Lembert's sutures are added, but reliance is mainly placed on a plastic inflammation, due to the pressure of the button, producing union before the button itself works loose in the intestine.

3. A rigid cylinder of decalcified bone (the so-called " bobbin ") is introduced, and over this the two ends of the bowel are drawn and so united as to cover in the cylinder. The cylinder, or bobbin, facilitates the introduction of the stitches, and so shortens the time taken in suturing ; it also acts as a temporary splint, and allows the passage of intestinal contents through its lumen. It may be noted, however, that it soon becomes digested or works loose.

4. One end of the bowel is invaginated into the other. If possible, the upper end is introduced into the lower.

Invagination is now chiefly employed in the form of Maunsell's opera-
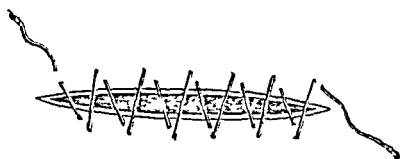
Fig. 92.—DUPUYTREN'S SUTURE.

tion, and then only as a temporary method to aid accurate suturing (*see* page 328).

5. The divided margins of the bowel to be treated are brought together by means of some form of suture. This is effected without employing any supporting foreign body, and without producing any invagination of the tube.

A great variety of *sutures* has been devised to effect this object.

Qualifications of a Good Suture.—An efficient intestinal suture should have the following qualifications :—

1. It should bring into contact two broad surfaces of peritoneum, these surfaces belonging respectively to the bowel above and below the breach to be closed.

2. It should effect a complete closure of the wound, the test being that the seam should be water-tight.

3. The suture should be simple, should be easily introduced, and should be capable of effecting a rapid closure of the wound.

4. The thread should take so firm a hold of the tissues

that there is no danger of its "cutting out" when strain is put upon it, as may be the case if the viscus become distended.

5. The sutures passing through the mucous membrane should be reinforced by a second row, which includes only the outer coats of the bowel.

6. No unsupported suture should pass through all coats
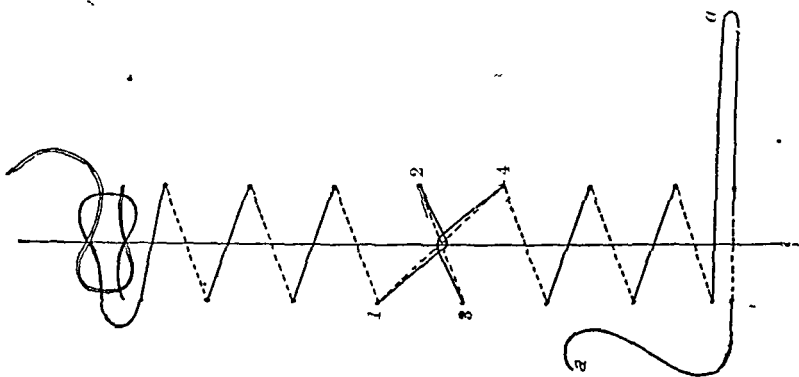
Fig. 93.—A CONTINUOUS SUTURE RUNNING FROM LEFT TO RIGHT.

A double knot is tied at the commencement. After traversing a short distance, the suture is tightened and secured by a loop (1, 2, 3, 4); at its end a second knot is made by tying the single thread (*a*) with the loop (*a'*) in a double knot.

of the bowel—*i.e.* it should not pass from the lumen of the gut to the serous covering of the same.

7. Special care should be taken at the mesenteric attachment to effect close union, as leakage is very apt to occur at this point.

The chief forms of intestinal suture will now be considered.

A. **The Continuous Suture.**—*Dupuytren's Method* (*Méd. Opér.*, vol. ii., page 138, Paris, 1822).—The edges of the wound are turned inwards, and the opposed folds of serous membrane are then brought together by means of the ordinary continuous suture (Fig. 92). The suture

does not involve the mucous membrane.   This suture may be very rapidly applied.

The method of commencing and finishing a continuous suture is illustrated in Fig. 93.

B. **The Interrupted Suture.**—*Lembert's Suture.* —The needle is passed transversely to the line of the wound, and at right angles to the axis of the bowel.

A fold is picked up upon one side of the wound; the needle is then carried over to the corresponding spot on the other side of the wound, where a precisely similar fold is picked up (Fig. 94). The margins of the wound are turned in, and the serous coats are brought into close contact (Fig. 95). The needle should pick up more than the serous coat; it should include a part

Fig. 94.—LEMBERT'S SUTURE.

or the whole of the muscular coat also.   It must on no account trespass beyond the limits of the submucous layer (Fig. 95).

The width of the fold picked up will be from one-tenth to one-twelfth of an inch.

The closeness of the sutures to one another must vary somewhat according to circumstances. They may be usually estimated at about ten to the inch.   It will rarely be safe to apply them less closely than this.   As shown in Fig. 94, a number are inserted before any are tied.
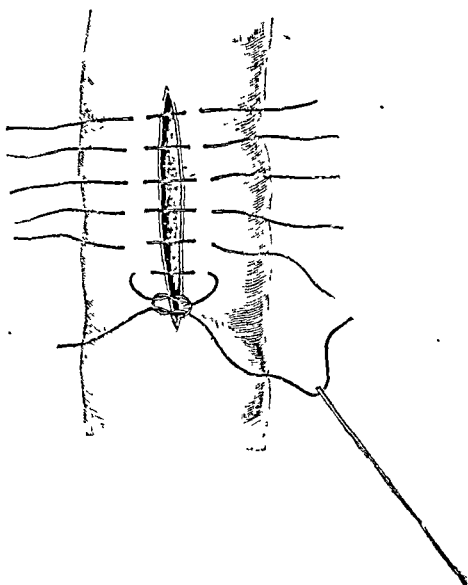
The extremities of each suture are knotted together, and the ends cut short.

Much trouble is saved, and the inconvenience of a long, wet, and sticky thread is avoided, if separate threaded needles are prepared for each suture.

If the supply of needles be limited, the thread carried by each needle may serve for two, or at the very utmost for three, sutures.

No form of intestinal suture can surpass Lembert's for general usefulness.

c. **The Invagination Method.**—This has been applied only in instances in which the whole circumference of the bowel has been divided.
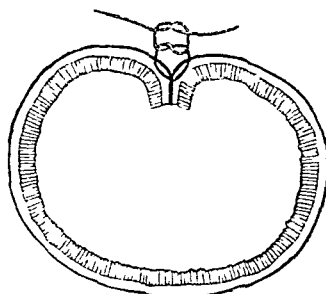
Fig. 95.—LEMBERT'S SUTURE

Maunsell's Method. — The principle of this method is to secure close apposition of the ends of the gut by a row of sutures which pass through all the coats of the intestine from within outwards, and with the knots placed on the inside of the gut.

The portion of the intestine having been excised, the two ends of the bowel are brought together by two temporary sutures which pass through all the coats of both ends of the gut. One suture is placed at the mesenteric attachment of the bowel *b*, and the other at the free margin *a* (Fig. 96, A). The ends of these sutures—which are loosely knotted—are left long. An opening is now made at *c* (Fig. 96, B) in that segment of gut which is the larger of the two—*i.e.* in the proximal part. The incision is on the free border of the bowel, and in its long axis. It will be placed about an inch from the free end of the gut, and its size will depend upon that of the gut to be invaginated. The ends of the ligatures *a* and *b* are introduced into the lumen of the incised bowel, and are brought out through the incision *c* (Fig. 96, B). They are then dragged up so as to invaginate the bowel, and ultimately to
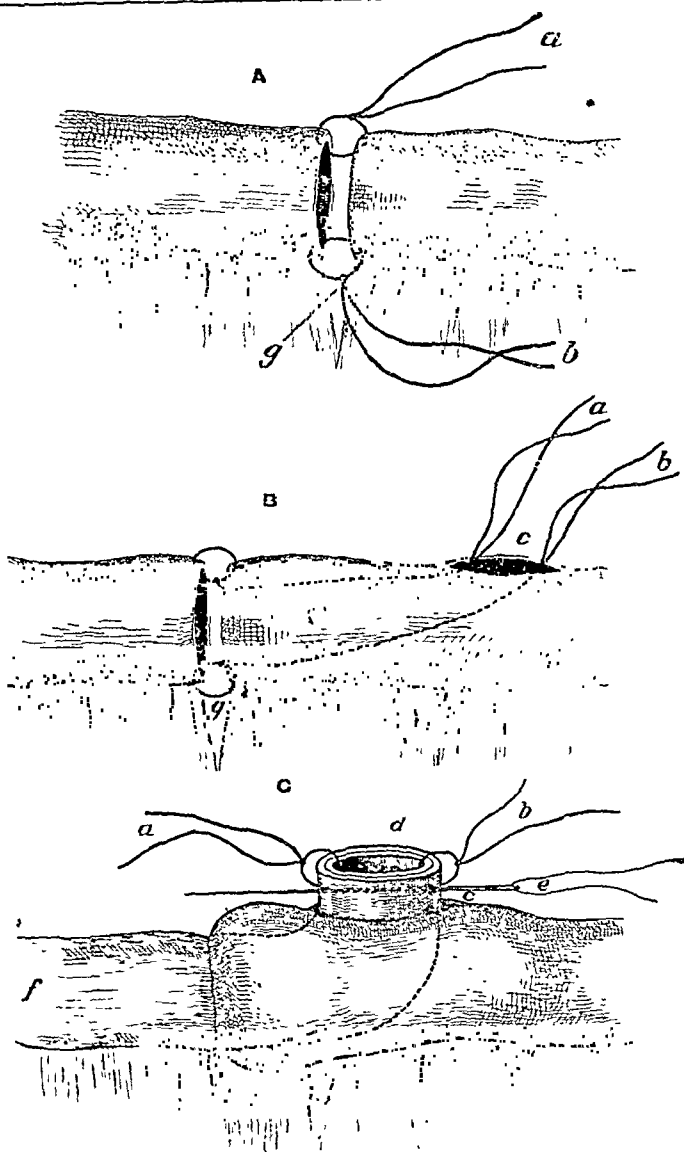
Fig. 96.—MAUNSELL'S METHOD OF UNITING INTESTINE BY THE PROCESS OF INVAGINATION. (For references, *see* text.)

bring out the two divided ends of the intestine *d* through the incision *c* (Fig. 96, c). The surgeon now passes a fine straight needle *e* through both sides of the double tube of bowel *d*. The suture is hooked up where it crosses the lumen of this tube, is divided, and tied on either side. In this way twenty sutures can be introduced with ten passages of the needle. The sutures are of fine silk, and serve to unite the divided intestine. Finally, the ligatures *a* and *b* are removed, and the sutured gut *d* is withdrawn (in the direction *f*), the invagination being thus reduced. The united bowel will now appear to be quite straight, and no sutures will be visible.

D. Adjustment by the Intervention of Foreign Bodies. *Suture over a Decalcified Bone Bobbin.*—Mayo Robson's bobbin (Fig. 91) is the best form to employ; it is kept, ready decalcified in spirit, in various sizes. In performing end-to end union of the intestine the largest bobbin that will fit the intestine is selected. Before introducing it, a continuous suture of silk (some employ catgut) is started on the posterior halves of the intestinal ends. This suture traverses all the coats, except the serous and outer muscular coats. The bobbin is now inserted, and held in place between finger and thumb of the assistant (acting through the intestinal wall). The continuous stitch is then carried all round the cut edges with here and there interruptions to make the suture tight. A second row of Lembert's interrupted sutures, which traverse only the outer coats down to the submucous layer, completes the union. Instead of these, the outer suture may be made continuous, but in our belief nothing ensures such perfect apposition as Lembert's interrupted stitches. Especial care is bestowed on the mesenteric border. The bone bobbin is probably of use only for a few hours after the operation (*see* page 325).

Murphy's Button.—The method of employing the button (attempted modifications of which have at present effected no improvement) will be gathered from the accompanying figures (97, 98, and 99) more readily than from a long description.

The two ends of the intestine are clamped or held between the fingers of an assistant some distance from their cut edges.   A running silk suture is rapidly carried round each edge, traversing all the coats ; it should begin at the mesenteric attachment, and its free ends are not tied.

In performing lateral anastomosis or gastro-jejunostomy
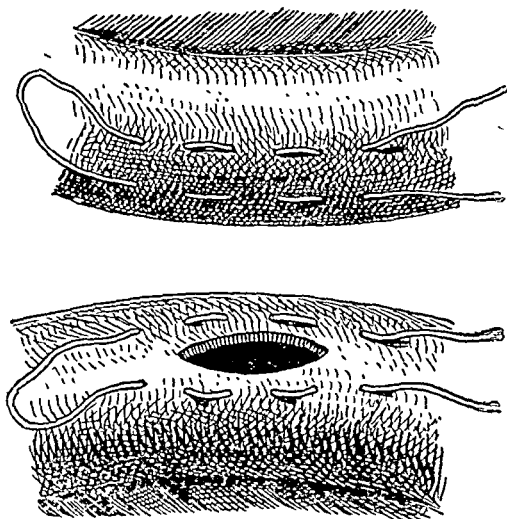
Fig. 97.—INTESTINE READY FOR THE INTRODUCTION OF MURPHY'S BUTTON.

(In the upper figure the suture is inserted.   In the lower figure the incision for the insertion of the button has been made.)

the running suture is introduced before the intestine is opened.   This suture is arranged as shown in the figure, and passes only through the serous and muscular coats of the bowel.

The two halves of the button are then inserted by means of forceps ; the lumen of each half may be lightly plugged with cotton-wool, which is, of course, removed just before they are fitted together.   The heavy "male" half is inserted into the lower segment of bowel, or in gastro-

jejunostomy into the jejunum.   The stitch is tied securely
round the narrowest part of each half, and is cut short.
Any redundant mucous membrane is cut off with scissors.
The two halves are then fitted to each other, care being
taken that they are pressed home with just sufficient force
to secure close approximation.   It is in this manœuvre that
accidents are apt to occur; the halves of the button may
jam, the ends of the bowel may be twisted in bringing them
together, or the buttons may be forced together too tightly.
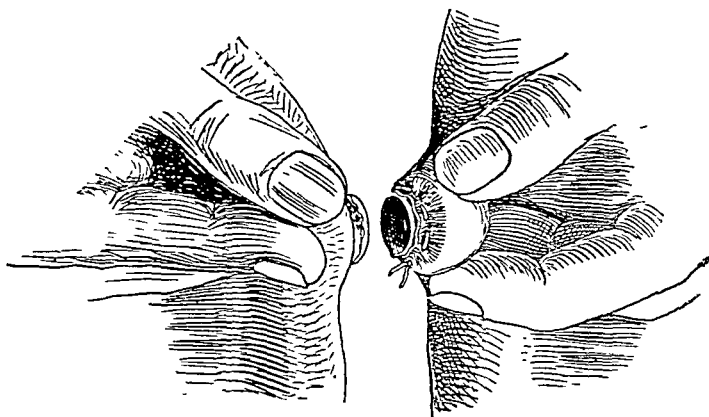
Fig. 98.—MURPHY'S BUTTON IN LATERAL ANASTOMOSIS.

Showing the method of holding the button when bringing the two
halves together.

The mistake has occasionally been made of trying to fit
buttons of two different sizes together.   Finally, a few
Lembert's sutures may be applied, but they are not
essential.

The time taken in placing the sutures and button need
not exceed ten to fifteen minutes, whereas any other satis-
factory method will take from thirty minutes to an hour.

Best Form of Intestinal Suture.—In discussing
this question, operations on the stomach may well be in-
cluded with those on the intestines.   What holds good with

regard to end-to-end union or lateral anastomosis of in-
testine applies equally to gastro-jejunostomy, etc.   The
chief point to be considered is whether *Murphy's button* or
a *double row of sutures* should be employed.   No other
mechanical appliance than the button has proved really
effective, Mayo Robson's bobbin being merely an aid to
suturing.   The bobbin, however, may be of decided use,
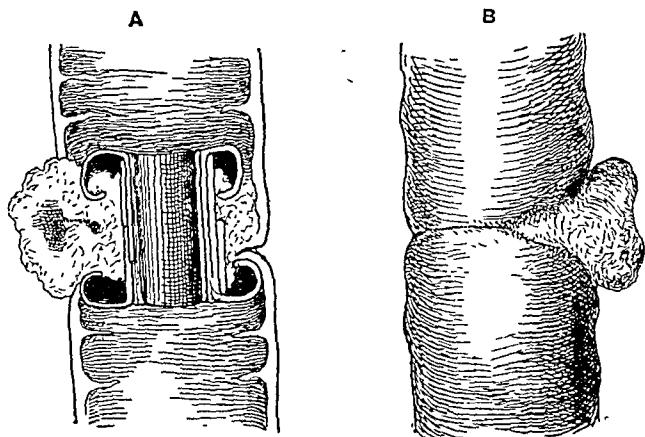
Fig. 99.—MURPHY'S BUTTON USED IN END-TO-END UNION.

From a specimen placed in the Royal College of Surgeons Museum by
Mr. P. Furnivall.

A, Sectional view of intestine, shows the button *in situ*; B, External
view of intestine; the lateral projection is composed in part of fat
at the mesenteric border.

especially in certain cases, such as in the closure of a fæcal
fistula.

It was thought at one time that the use of Murphy's
button, with its very conspicuous advantage of rapidity in
operating, would supplant simple suturing.   Most surgeons
have, however, after trial of the button, returned to the use
of direct suture.

The *interrupted sutures* have many advantages.   The
strain   upon   the   wound   is   distributed   over   many

threads. The surfaces concerned are brought into very accurate contact. The vascular supply of the margin of the wound is not interfered with. The sutures are easily introduced, and the amount of suture material employed is reduced to a minimum. The securing of these sutures, however, involves considerable time ; and, unless they are very closely placed together, there is some risk of leakage in the gaps between the threads.

Lembert's suture has stood the test of time, and it may be safely said of it that it is, on the whole, the *best form of suture* with which we are acquainted.

CHAPTER V.

Resection of the Intestine.

UNDER this title are included operations which concern themselves with the removal of comparatively small portions of either the small or the large intestine.

Excision when applied to the lesser bowel is termed enterectomy, and when carried out in the colon, colectomy.

The details of the operation will be considered under the following headings :—

1. Enterectomy with circular suturing of the divided ends.
2. Enterectomy with the aid of Murphy's button.
3. Enterectomy with the establishment of an artificial anus.
4. Methods of uniting segments of intestine of unequal size.
5. Colectomy.

I. ENTERECTOMY WITH CIRCULAR SUTURING OF THE DIVIDED ENDS.

1. The abdomen having been opened, the first step is to isolate the loop of intestine to be excised. This loop should be drawn well out of the parietal wound. Any adhesions which prevent it from being well exposed and isolated must be divided.

If any extravasation has taken place into the abdominal cavity, it should be dealt with before the resection is commenced.

The part to be resected is placed upon a flat sponge, and the whole wound through which the intestine has been drawn is well and carefully packed all round with gauze or sponges. It should be impossible for any intestinal matter to find its way into the peritoneal cavity.

2. The bowel must be occluded above and below the

resection area. If sponges have been well packed all around
the coil, this precaution may sometimes, and in some special
cases, be dispensed with.

Many clamps have been devised for the present purpose.
No instrument, however, is so efficient as the fingers of an
intelligent assistant.

Of the various clamps devised, that introduced by Mr.
Makins is useful. The blades are covered with indiarubber
tubing, and are long enough to compress the whole width of
the bowel. They are simple, and are easily applied and
removed. Another useful clamp is that known by Doyen's
or Hartmann's name, though it is practically identical with
that introduced previously by Sir T. Smith.

In adjusting clamps (should these instruments be used)
the upper clamp will be applied first. The segment of bowel
to be excised will then be gently emptied by passing the
fingers along it, and the lower clamp will be fixed in posi-
tion. Little matter should therefore escape from the isolated
segment during the division of the coats of the bowel. Before
applying the sutures, care must be taken that the bowel
above the resection area is not greatly distended. If it be
so, the distension must be relieved, as much gas and fæcal
matter being allowed to escape as will find an exit. This is
best effected by making an opening in the centre of the loop
to be excised, and allowing the intestinal contents to escape
into a gutter of thin indiarubber tissue which has been
already prepared and put in position. This answers better
than the method of loosening the upper clamp after the
bowel has been excised.

3. The portion of diseased bowel is now excised. This
is effected with blunt-pointed scissors. The cut must be
made about three-fourths of an inch beyond the margin of
the clamp. If it be much nearer, it will be found that the
clamp interferes with the movement of the needles during
the passage of Lembert's suture.

The scissors cut their way from the free border towards
the mesentery; on approaching the mesentery care must
be taken to save as much of that membrane as possible.

Another—and in most instances a better—method of

treating the mesentery consists in excising a triangular portion of the membrane together with the gut to be removed. The base of the triangle will be at the intestine, but will be narrower than the length of bowel removed. By allowing the mesentery to overlap the divided ends, as it were, the vascular supply of those segments is the less interfered with. The margins of the wounds in the mesentery are then carefully brought together by a continuous suture.

4. The divided ends of the bowel are now thoroughly well cleansed, and all soiled sponges are removed and replaced by fresh ones.

The mucous membrane may be found to protrude considerably, and to appear to interfere with the proper adjustment of the sutures. On no account, however, should any portion of this membrane be pared away.

The sutures may now be applied. If it is intended to introduce a double row, then the surgeon proceeds at once to unite the margins of the divided mucous membrane.

In an operation like the present, where time is usually a matter of considerable importance, the inner row of sutures may be dispensed with, or may at least be replaced by a continuous suture, which can be rapidly introduced.

The surface sutures will be applied according to Lembert's method, and in the manner already described.

The weak part of the suture line will be at the mesenteric border. It is at the line of the attachment of this membrane that the first stitches are applied. Use must be made of any peritoneum which has been saved from the mesentery, and sufficient must be found to serve as a covering for the bare portion of the bowel. Not only must the muscular coats be well brought together at this part, but inturned flaps of peritoneum covering that coat must also be brought into direct and close contact.

After the mesenteric border has been dealt with, it is most convenient to turn next to the free or opposite border of the intestine, and to insert three or four sutures there.

The surgeon may then introduce a batch of three or four sutures upon the lateral parts of the bowel, at points on either side, midway between the first two sets of sutures.

Finally, the gaps between the four isolated batches of sutures are filled up, and the union of the divided ends is completed.   The clamps are now removed.

The surgeon next turns to the mesentery. If a triangular portion has been removed, the margins of the gap are brought together by several points of suture—or, better still, by a continuous suture.

5. The bowel is well cleansed, the sponges that have held the coil in place are removed, and the sutured loop is allowed to drop back into the abdomen. The abdominal wound is then closed ; and, unless distinct reasons exist to the contrary, no drainage tube is introduced.

The application of the sutures is much aided by the use of a *bone bobbin.* This bobbin is especially of use in closing a fæcal fistula and the gap left by colotomy. In many of these cases the absolute division of the bowel into two parts may often be avoided. If the bowel has been completely divided, the mucous membrane about the attached part of the gut is united. When about half the circumference has thus been sutured the bobbin may be introduced and kept in place by an assistant. The union of the divided mucous membrane is then completed ; and finally the outer coats are united by means of a closely placed series of Lembert's sutures.

II.—ENTERECTOMY WITH MURPHY'S BUTTON.

The method of performing this has already been described.

It should be noted that in resection of intestine, and still more in gastro-jejunostomy, the heavier part of the button should be inserted into the lower segment of the bowel.   Care should be taken to press the two halves together with just sufficient force, and not to rotate or twist the segments of bowel in bringing them together.   It is advisable to insert a few Lembert's sutures, especially towards the mesenteric attachment. Any redundant mucous membrane should be cut off before bringing the two halves of the button together.   The button is usually passed *per rectum* at the end of two to three weeks if the patient does well.

III.—ENTERECTOMY WITH THE ESTABLISHMENT OF AN
ARTIFICIAL ANUS.

The early steps of the operation are as described in
Section I. (pp. 335 *et seq.*).

The removal of a triangular piece of the mesentery facili-
tates the subsequent closure of the artificial anus. The gap
left in the mesentery should be united by suture, as described.

After the excision has been carried out, the wound in the
parietes is so far closed as to leave only a gap through which
the divided ends of the gut project. The two sections of
bowel—still clamped—should be brought together by their
mesenteric borders, and are united by a few points of suture.
If time and the condition of the patient allow, the union of
the two ends may be carried a little to either side of the
mesenteric border. The mucous membrane over the uniting
isthmus should be brought together by a simple continuous
suture. This partial union of the gut greatly facilitates the
operation for the subsequent closure of the fæcal fistula.

The lower end of the divided bowel is now rapidly united
to the parietes. The margin of the bowel is secured all round
to the margin of the parietal wound. The serous covering
of the intestine must be brought into contact with the serous
lining of the abdominal wall.

The main sutures may be passed before the clamp is
removed, and may be drawn tight and secured when the
clamp is withdrawn.

The upper end of the bowel is dealt with in the same
way. Every preparation must be made for a rush of fæcal
matter as soon as the upper clamp is removed. The main
sutures will be in place before the clamp is withdrawn. A
plug of wool in the lumen of the gut will very often serve to
keep the wound dry. The intestinal contents may be received
upon a layer of oiled lint, which is frequently changed. A
Paul's glass tube may be used with advantage in each end
of the bowel.

IV.—METHODS OF UNITING SEGMENTS OF UNEQUAL SIZE.

The bowel above the segment resected may be much
dilated, while the tube below is much contracted. In such

a case the two parts to be united may be brought to more . nearly the same size if the distension of the upper part of the bowel be relieved by allowing . its contents to escape. Moreover, after the excision, and before the sutures are applied, the lower clamp may be loosened, and the con-tracted bowel gently stretched to the necessary size with the fingers, after which the clamp may be reapplied.

In actual practice, however, these measures are usually not called for. If the bowel about the part to be removed be greatly dilated, and the bowel below be greatly con-tracted, there must have been a severe grade of intestinal obstruction, and in such a condition the enterectomy should be concluded by establishing an artificial anus.

When, however, the cæcum has been excised, and the ileum has to be united to the colon, one or other of the following measures may be adopted :—

1. **Wehr's Method.**—The end of the narrower part of the bowel is not divided transversely, but is cut obliquely. The obliquity must be· such that the oblong opening which results shall correspond to the lumen of the other end of the bowel. This unequal division of the intestine must always be made at the expense of the convex or free margin of the gut. It has the drawback of pro-ducing a bend or kink of the intestine.

2. **Billroth's Method.**—This is known as lateral implantation. Assuming that the cæcum has been excised, the end of the colon is closed by sutures. This is effected by invaginating the free margins of the divided gut, so that the serous coats are brought into close contact. The parts are united by sutures, preferably by a double row.

A slit is now made in the wall of the closed colon. This slit is vertical—*i.e.* in the long axis of the colon—is placed upon that margin of the gut which is opposite to the attachment of the mesocolon, and is situate about two inches from the closed end. The ize of the slit will correspond to the size of the divided end of the ileum.

The end of the ileum is implanted in the slit, and is secured there by very careful suturing.   -

V.—COLECTOMY.

The operation for resecting portions of the colon differs in no essential particular from that applied to the small intestine.

After the diseased segment has been removed, the two divided ends of the intestine may be brought together and united by sutures, or any attempt at immediate union may be abandoned, and an artificial anus be established. In colectomy the latter procedure is more frequently carried out than is the case when the small intestine is dealt with.

An artificial anus may be established as a temporary measure, and may be followed by an attempt to close the opening at a later period by a second operation. In such a case the two ends of the divided colon are brought close together, and may even be united partially by a few sutures applied upon the deep or attached aspect of the gut.

If, on the other hand, it be intended that the artificial anus should be permanent, then it is well to close the opening in the distal segment of the bowel. This especially applies to resections carried out low down in the colon.

In closing the distal end it is well to turn in the edges a little, and to bring the serous coats of the bowel together so far as is possible.

The best position for the incision in the parietes offers some difficulties. The most practical rule is that which would direct the incision to be made immediately over the tumour when a tumour exists.

In any case of doubt a small exploratory incision should be made in the median line, and this may be followed if necessary by a second incision directly over the seat of the disease.

The *bone bobbin* will be found to be of much use in the suturing of the large intestine after resection. *Murphy's button* is also of great use in dealing with the colon, as it is readily and certainly discharged. It is in connection with the colon, indeed, that Murphy's button will be found to be the most useful.

CHAPTER VI.

Intestinal Anastomosis.

By intestinal anastomosis is understood the establishment of a permanent fistulous communication between the intestine above and the intestine below the seat of some more or less permanent obstruction.

1. **Lateral Anastomosis by Suturing.**—The two pieces of intestine which it is intended to join together are drawn out of the abdominal wound and supported by warm sterilised compresses or flat sponges. The contents are expelled by gentle pressure, and clamps applied above and below the site of anastomosis. Smith's or Hartmann's clamps will be found convenient. The free surfaces of either piece of intestine are turned towards each other, and it is ascertained that they can be easily made to lie in contact, and that the clamps do not interfere with this. On the convex surface of each intestinal loop a continuous suture of fine silk, which traverses the coats down to the submucous layer, is passed, and tied at either end. The suture follows the axis of the intestine. Just in front of this the intestine is opened for from one and a half to two inches by a longitudinal incision made with a tenotomy knife or fine scalpel, and enlarged with fine scissors. Any fluid contents which have remained after clamping are wiped away. A continuous suture—fastened off at short intervals by knots—is then carried through the whole thickness of the circumference of the wound on either side. Finally, a continuous suture is passed through the outer coats of the intestine in front of the anastomotic opening. The clamps are removed as soon as possible, a few Lembert's stitches applied wherever it seems advisable, and the loops returned into the abdomen after gentle cleansing.

2. **Lateral Anastomosis with Mayo Robson's Bobbin.**—The only difference between this method and that just described is the following : After the posterior continuous suture has been made, the intestine opened, and the second suture carried half-way round the opening, a decalcified bone bobbin is inserted, and the suturing continued in double row in front of the bobbin. The use of the latter is supposed to render the operation quicker and the suturing easier. As already noted, it is probable that the bone bobbin remains in place only a few hours, as the digestive juices cause it to be rapidly absorbed.

3. **Lateral Anastomosis with Murphy's Button.** —This is the quickest method but the least trustworthy, as it depends on a slough being formed, and involves a heavy metal body being left in the intestine, which may easily give trouble later. It is, however, so simple that it can be effected in a few minutes, and no detailed description is required beyond that already given (page 330).

Murphy's button is best suited, and is indeed well suited, for anastomosis involving the colon.

CHAPTER VII.

Enterotomy.

The term enterotomy is applied to an operation which is carried out in cases of intestinal obstruction, and which consists in opening the distended bowel above the seat of the occlusion and allowing its contents to escape. This involves, of course, an abdominal section.

The procedure is sometimes known as "Nélaton's operation." It is assumed that the loop of bowel which is opened will belong to the small intestine, and in the majority of instances this proves to be the case. It has always been considered a feature of the operation that, after the abdomen has been opened, the most convenient distended coil which presents should be incised and a fæcal fistula forthwith established. It will be obvious that the term enterostomy would more precisely represent this operation than the term enterotomy, which would imply the mere cutting into the bowel, as in the removal of an impacted gall-stone.

The Operation. — The abdomen is opened in the right iliac region—if Nélaton's method be strictly followed —by an incision parallel to and a little above the outer part of Poupart's ligament.

The incision is placed to the outer side of the epigastric artery, and its length must depend upon the thickness of the parietes. One inch and a half and three inches will represent the extremes. French surgeons advise a cut of 7 cm. (2¾ inches).

As soon as the abdomen is opened, the first distended coil of intestine that presents is seized and drawn into the wound. It will probably belong to the lower ileum.

The convex part of the distended knuckle is drawn well into the parietal wound, but the convex or free border should alone project.

The gut should not be twisted from its natural position
—that is to say, the spontaneous direction it has assumed
should be preserved.

The wound in the abdominal parietes is now partly
closed by means of silkworm-gut sutures which are intro-
duced at the two extremities of the wound.

The bowel will occupy the centre of the wound, and a
sufficient number of sutures (two probably on either side)
must be introduced to fix the gut in place by the mere
narrowing of the parietal incision.

The sutures must include all the tissues forming the
parietes, together with the peritoneum.

The latter membrane should be brought as near to the
cut margin of the skin as is possible.

It will be found that a curved Hagedorn's needle of large
size is the most convenient for introducing the sutures.

The wall of the bowel is now rapidly stitched to the
margin of the skin, which tightly surrounds it on all sides.
Very fine silk, passed by means of a small curved needle
held in a holder, is best adapted for this purpose. The
stitches should involve the skin and the serous and
muscular coats of the bowel. Care should be taken not
to open the actual lumen of the gut with the needle.
In cases of great distension this is not easy. To save time,
two operators may be engaged simultaneously upon this
stage of the procedure.

A Paul's glass-tube of small calibre is now taken up
and the diameter mentally marked on the intestine. A
purse-string suture is then made to circumscribe the area to
be incised, both ends of the suture being left long. With a
tenotome or fine scalpel the intestine is opened within the
area, one edge of the wound held aside with fine forceps,
and the tube introduced. The suture is now tied firmly
round the groove in the tube ; the latter is packed round
with sterilised gauze, the distal end of the tube being
provided with a long and thin rubber tube along which the
contents as they escape can be conveyed into a receptacle
containing a disinfectant. A large dressing of cotton-wool
held in place by a bandage completes the operation. The

glass tube comes away, as a rule, in five days. As the contents of the small intestines are comparatively fluid, the Paul's tube need not be so large as that employed in colotomy.

Supposing that a Paul's tube is not at hand, the following procedure is employed :—

The gut is opened by a small puncture. This should be effected with a scalpel, and not with a trocar.

Before the incision is made, the united parts of the parietal wound should be buried in iodoform, and the contents of the bowel should be allowed to escape upon a sheet of lint well covered with vaseline.

The small sutures that connect the gut wall with the skin are for the purpose of shutting off the peritoneal cavity. They will not suffice probably to hold the intestine safely in position.

To effect this latter object two lateral sutures of silkworm gut should be introduced, and should transfix the whole thickness of the intestinal wall except the actual mucous membrane, and take a firm hold of the integuments.

These sutures should be passed from without inwards, *i.e.* from the skin towards the gut. If passed in the opposite direction, they might carry fæcal matter into the tissues.

The opening into the bowel should always be small, and should be upon the free or convex border.

The smaller the knuckle of intestine brought into the wound, and the smaller the fistula, the easier will be any subsequent operation for the closure of the artificial opening.

The operation as above described can be carried out in a remarkably short space of time, and with the least possible amount of disturbance of important structures.

After the gut has been incised, there should be no squeezing of the abdomen, and no attempt to wash out the lumen of the bowel. The distended tube should be left to empty itself in its own way, and the less the process is interfered with the better.

A light dressing of absorbent wool, which may need to be changed at first every few minutes, is all that is needed.

The skin around the opening should be frequently dried, and then covered with vaseline.

CHAPTER VIII.

Colotomy.

By colotomy is understood the operation of establishing an artificial anus in the colon. This may be either temporary or permanent.

Colotomy is carried out for the relief of obstruction in the colon of various kinds, and is most frequently employed in cases of cancer of the rectum. It is performed also as a palliative measure in some examples of cancer of that part in which no obstruction exists.

Lumbar colotomy implies the opening of the ascending or descending colon through the loin without wounding the peritoneum. This is known also as the extraperitoneal operation, as posterior colotomy, or the operation of Amussat and Callisen. The idea of the operation—which belongs to the pre-antiseptic days—is to open the colon without wounding the peritoneum. The method is now almost obsolete.

Inguinal colotomy implies the opening of the sigmoid flexure, or the cæcum, through an incision in the iliac region which involves the peritoneal cavity. This is known as the intraperitoneal operation, as anterior colotomy, as Littre's operation, as laparo-colotomy, and as inguinal colotomy.

Lumbar colotomy has been almost entirely abandoned in favour of the inguinal operation. Indeed, a colotomy in the loin has become a very rare operation.

LUMBAR COLOTOMY.

Instruments required.—Scalpels; straight and curved scissors; dissecting, toothed, and Wells's forceps; broad rectangular retractors; Hagedorn's needles, of various sizes, and needle-holders; blunt hooks; sutures and ligatures.

Position.—The patient should lie upon the sound side and close to the edge of the table. A small hard pillow or sandbag is placed under the opposite loin, so that the region to be operated upon may be brought well into view, and the space between the crest of the ilium and the last rib be extended to the utmost (Fig. 100). In very corpulent sub-
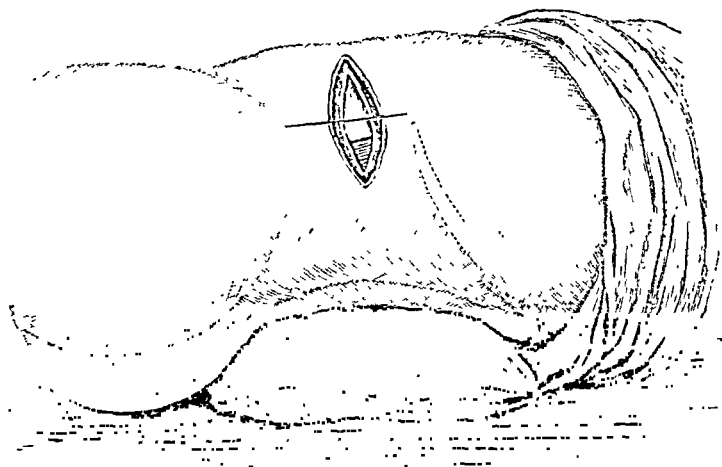
Fig. 100.—THE INCISION IN LUMBAR COLOTOMY.
(The quadratus lumborum muscle is exposed.)

jects, and in cases in which there is considerable distension of the abdomen, this pillow may be dispensed with. The surgeon stands upon the side to be operated upon; the chief assistant is facing him, and upon the opposite side of the table. He attends to the sponging, and assists in holding the gut when it has been secured. An assistant may stand upon either side of the operator, and may attend to the retraction of the wound.

First Stage.—The incision should be from three to three and a half inches in length. It is placed obliquely, midway between the last rib and the iliac crest. Its centre should correspond to the centre of the line marking the

site of the bowel (Fig. 100).   It will be about parallel
to the last rib, or will follow a line drawn from the
anterior superior spine to the angle between the twelfth
rib and the mass of the erector spinæ muscle.

The length of the incision will be mainly influenced by
the thickness of the tissues, and this for the most part
will depend upon the degree of corpulency.   The tendency
is rather to make the incision too long.

After the skin and superficial structures have been
divided, the external oblique and latissimus dorsi muscles
will be exposed.   The fibres of these muscles are in this
situation vertical. They should be divided by a single clean
cut through the whole length of the incision.

The layer of the internal oblique will next come into
view.   The fibres are found running somewhat obliquely
upwards and forwards.   This muscle is also cleanly divided
through the whole length of the original wound.   In the
posterior part of the wound the fascia lumborum will
probably come into view.

There are now exposed a few of the hindermost fibres of
the transversalis muscle, which are nearly transverse in
direction, and the fascia lumborum. If the incision has been
made as described, the actual amount of muscle tissue ex-
posed in the depths of the wound will be slight.

The muscle and the fascia are now divided to the full
length of the wound.   Before this division is made it
will probably be noted that the twelfth dorsal nerve, accom-
panied by the abdominal branch of a lumbar artery, is
crossing the area of the operation.   It is as well to avoid
cutting the little artery.

In the posterior part of the incision the clear anterior
border of the quadratus lumborum will be seen (Fig. 100).
The fibres of that muscle seldom, if ever, need to be divided.
Broad rectangular retractors will be found very useful at
this stage of the operation.

A little fat may now come into view, and be mistaken
for the subperitoneal tissue. It is the fat beneath the
transversalis fascia.

This fascia must be sought for and demonstrated, and

cleanly divided to the full length of the wound. It is well to commence the division close to the anterior border of the quadratus lumborum.

The subperitoneal fat is now reached, and the first stage of the operation is completed.

No director is needed, and in no operation is that dangerous weapon more out of place.

The parts should not be divided with scissors. All that is needed is a scalpel and a pair of dissecting forceps.

The operator will seldom be delayed by the need of applying pressure forceps to a bleeding point.

The chief error in this stage of the operation is due to the ignoring of the transversalis fascia and the failure to completely divide that structure.

Second Stage.—The gut is now sought for. When great distension of the abdomen exists, the colon very frequently bulges at once into the wound as soon as the tissues around it have been freed by the finger.

Failing such an appearance, the forefinger is introduced into the subperitoneal tissue and the colon is sought for. The finger follows the anterior surface of the quadratus lumborum, and seeks for the angle which exists between this muscle and the psoas.

It is towards this angle that the non-peritoneal surface of the colon faces in cases where no mesocolon exists. In seeking for this part the lower end of the kidney will be felt, and it must be remembered that the bowel lies on a plane anterior to it.

It is essential that the subperitoneal fat be well opened up with the examining finger or fingers. The exposure of the non-distended bowel is impossible unless this be done.

In corpulent subjects an immense thickness of tissue will have to be ploughed through before the colon is reached.

The bowel may perhaps be recognised in the depths of the wound by the thickness of its coats or by the presence of a scybalous mass. In such case it should be gently freed and drawn into the more superficial part of the wound for examination.

The surgeon must be convinced that his fingers are behind the peritoneum—which he is, indeed, separating from the posterior parietes—and that the subperitoneal fat has been fully opened up.

Assuming that the colon has not yet been discovered, the curved forefinger should be placed in the angle between the psoas and quadratus lumborum muscles, and the patient should then be rolled over almost upon the side operated upon.   The bowel that falls into the finger cannot well be other than the colon.

Failing the rolling over of the body, the assistant who faces the surgeon may press upon the anterior abdominal parietes so as to force the intestines towards the loin.

The surest guide to the non-distended colon is the feeling which is communicated when its coats are picked up between the forefinger and the thumb.

The gut, when brought into view, may be identified by the thickness of its coats, by its non-peritoneal surface, and possibly by the existence of a longitudinal band.

The band which comes into view is that known as the posterior.   The bands of the large intestine are well seen in the ascending colon, but are less clearly marked in the descending segment of gut, the longitudinal layer of muscle becoming more evenly spread over the colon as the rectum is approached.   The colon can be recognised by many means, without wasting time over a search for the posterior longitudinal band.

The sacculi of the colon cannot be demonstrated, as a rule, through a lumbar colotomy wound.   They are valueless as a means of identification.

The appendices epiploicæ can only be seen when the peritoneum has been opened, and when the colon has been drawn through the rent.

In the search for the bowel great service is rendered by good broad rectangular retractors and a good light.

When a distinct mesocolon exists, and the colon is empty, the peritoneal cavity must of necessity be opened up and a loop of the intestine drawn through.

If, however, the mesocolon can be identified—and on the

left side a branch of the inferior mesenteric artery may indicate it—the separation of its two layers is not as a rule difficult.

If the peritoneum has been opened, it is of little use to waste time in attempting to sew up the rent, as advised by some. In the deep wounds which are inevitable in corpulent subjects the closure of the gap in the membrane may be almost impossible. The rent made will most probably be large and irregular, and may be internal to the bowel.

Third Stage.—The bowel is fixed in position and opened. If the colon do not come readily into the wound, or if there be difficulty in retaining it, its walls should be seized in a vertical direction by long pressure forceps. No more of the coat of the bowel should be picked up in the forceps than is required to give a hold for the instrument. It is in the part so held that the future opening may be made.

It is needless to observe that the opening must be made in the non-peritoneal segment of the bowel, and therefore upon its posterior surface.

Gentle pressure exercised upon the front of the abdomen will help to keep the gut in position. The more completely the subperitoneal tissue has been opened up, the more easily can the bowel be brought into view. The bowel should be merely drawn to the level of the skin. It should not be dragged out as a loop or even as a knuckle.

By means of a large curved needle the two extremities of the parietal wound are now closed by sutures. Silkworm gut should be employed, and the needles should be passed very deeply, so as to include all the divided structures down to the fascia lumborum.

Probably two such deep sutures on either side of the centre of the wound will be sufficient.

They should all be passed before any are tied. When they are tied, the skin should very closely embrace the small dome of protruding bowel which, still held by the forceps, presents in the centre of the incision.

As the edges of the wound, at its lateral extremities, are being brought together, the bowel should be drawn a little

upon by means of forceps, with the result that the skin and the bowel wall are brought into close contact.

By means of a small curved Hagedorn's needle, the skin is in the next place united all round to the intestine by many points of suture. The needle should only concern the skin on the one hand and the muscular coat of the bowel on the other. The lumen of the gut should on no account be penetrated. Fine silk may be used for this purpose.

If this be well done, it is quite impossible for any fæcal matter to find its way into the depths of the wound ; and should there be a rent in the peritoneum, it will at least be efficiently shut off from communication with the surface.

The part is well dusted with iodoform. The hard pillow is removed, and the patient's body is a little inclined over to the affected side. A piece of lint well smeared with vaseline is at hand to form a surface over which the escaping fæcal matter may run.

Finally, the forceps are removed from the gut, and an opening is made into the bowel by means of a small scalpel. The opening is quite large enough if it will admit the point of the little finger. The amount of flatus and fæces that escapes varies remarkably.

By means of a curved Hagedorn's needle of medium size, or a curved needle in a handle, the final sutures are introduced. They concern the whole thickness of the coats of the bowel on the one hand, and the skin on the other. Silkworm gut should be the material employed.

The needle is introduced through the skin, and its point is made to appear in the interior of the bowel. A fresh needle and a fresh thread are employed for each suture. If the suture be passed in the opposite direction—*i.e.*, from the mucous membrane to the skin—a fæcal seton is practically drawn through the tissues.

Silk should not be employed, as it favours the passage of intestinal fluid along its fibres by capillary attraction. Of all ligature materials, it is the one least well suited for the present purpose.

In securing the bowel, it is well to avoid too many stitches, too large needles, and too thick suture material.

N

It is well also that the opening into the colon should be, at first at least, quite small.

INGUINAL COLOTOMY.

This operation has been rendered easier and more simple of late years, and the introduction of Paul's tubes has made immediate opening of the bowel a safe proceeding. Inguinal colotomy has almost entirely supplanted the lumbar operation, and is the operation to be chosen whenever the large intestine requires to be opened, provided that the obstruction is below the upper part of the sigmoid flexure.

Instruments required. — Scalpels and blunt-pointed bistoury; scissors; fine-pointed forceps; several Wells's forceps; blunt hooks; retractors; straight and curved needles; needle holders; silk sutures, etc. Sometimes a wooden, ivory, or glass rod is employed for fixing the intestinal loop outside the wound. A strip of gauze will serve the same purpose.

The Operation.—The chief points to be remembered are : (1) To make as short an incision through the muscular wall of the abdomen as possible; (2) to open the highest part of the sigmoid flexure that can be drawn into the wound without undue tension ; (3) to ensure an efficient spur being made out of the posterior wall of intestine.

By these means faeces are prevented from passing on into the rectum, prolapse of the intestinal wall is to a great extent avoided, and a certain amount of control over the artificial anus is obtained.

The exact position of the wound is not of great importance. A convenient guide is a line drawn between the umbilicus and the anterior superior spine on the left side; at a distance from the latter point of about one and a half inches a wound rather more than two inches long is made, crossing this line downwards and inwards. Or the incision may be made parallel to the outer third of Poupart's ligament, and from half to one inch above it.

The external oblique aponeurosis being divided to the extent of two inches, the internal oblique and the trans-

versalis are cut through to a less extent, dissociation of
their fibres being also employed. It is convenient to catch
each muscle as it is divided by Wells's forceps, which act as
retractors. The transversalis fascia, subperitoneal fat, and
peritoneum are then cut through. The forceps are then
transferred to the cut edges of the peritoneum, and the
surgeon proceeds to find the sigmoid flexure. It often
happens that the first loop to present is small intestine.
In this case it should be pushed inwards. The great
omentum should be treated in the same way. The operator,
working across the iliac fossa, recognises the sigmoid by its
being bound to the former by its mesocolon, and draws the
loop into the wound. Confirmation of its nature is obtained
by seeing the longitudinal bands and appendices epiploicæ.

The loop must be drawn forwards into the wound, so
that the whole circumference of the gut lies outside the
peritoneum. This is nearly always practicable, unless the
mesosigmoid be abnormally short. The loop should be
followed inwards until the highest convenient part is secured,
the rest being returned into the abdomen.

The next step is to fix the loop in position. This may
be effected in one of two ways. The simpler consists in
passing a wooden or ivory rod, three or four inches long,
through the mesosigmoid from side to side ; the rod then
rests on the abdominal wall and prevents the intestine
from being retracted.

The other method, which is perhaps the better one,
consists in passing a mattress suture of silk through the
muscular edge on one side, then through the mesentery,
the other muscular edge, and back again. The suture is
then tied. Whichever method be employed, two sutures
should be inserted to secure the sero-muscular coats of the
bowel to the skin at either end of the wound. Care
should be taken to replace any piece of omentum that
may protrude, and the stitches just mentioned will tend
to the avoidance of this accident when the patient strains
or vomits after coming round from the anæsthetic.

The surgeon now decides whether or not to open the
intestine at once. (1) If there has been no distension of

the abdomen before the operation, the opening may be deferred for three or four days. In that case soft sterile gauze is packed round and over the protruding loop, and a pad of cotton-wool kept in position outside this by a bandage or binder. A moderate dose of morphia or an opiate should be given the same evening if there is pain or restlessness. *At the end of three or more days the intestine* will adhere firmly to the wound and may be opened without
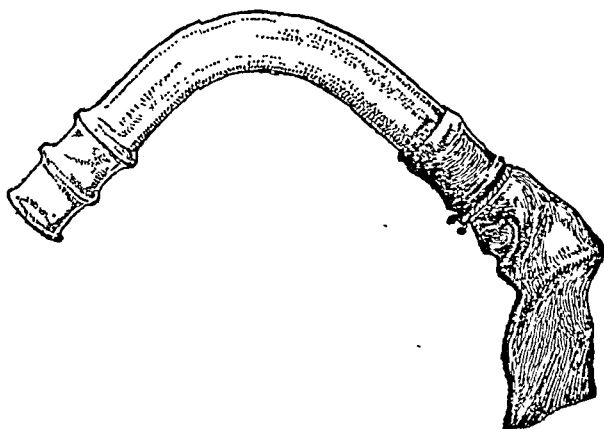
Fig. 101.—PAUL'S TUBE FOR COLOTOMY OR ENTEROTOMY
(about half-size).

The tube is made in three sizes. The commencement of the rubber tube
is shown tied to the glass one by a silk thread.

giving an anæsthetic. The rod or gauze which supports the loop should be removed. The opening is best made with scissors. If redundant intestinal wall be cut away, the arteries bleed freely, and should be clamped with forceps or tied with silk. The intestine seems to project unduly for a time, but it settles down. Many surgeons divide the gut completely across.

(2) If it be decided to complete the artificial anus whilst the patient is under the anæsthetic, a Paul's tube of suitable size should be inserted. On the convexity

of the intestine a purse-string suture of silk is placed, circumscribing an area of, say, an inch in diameter. In this area a linear opening is made, the edges are held aside by fine-toothed forceps, and the glass tube is introduced. The tube is so placed that its lumen is directed upwards, and the silk suture is firmly knotted round the groove on the tube. A soft rubber tube, some few feet in length, should have already been fixed to the other end of the glass tube, through which the intestinal contents may pass into a covered jar containing a disinfectant. The rubber tube can be dispensed with. It tends to pull the glass tube out of place. In this way the wound can be kept absolutely clean and the neighbourhood of the patient free from odour until the tube comes away after a few days have elapsed. The insertion of the glass tube, which should be large enough to allow semi-solid fæcal matter to pass through it, may be effected so quickly that no leakage occurs before the silk is tied. The tube is supported in position by a thick pad of gauze and wool around it ; this dressing is held in place by bandage. A cradle is used to keep off the weight of the bed-clothes, and the rubber tube may be conveniently attached to the side of the cradle and so carried out of the patient's bed.

Provided the tube does not get blocked, it may be left to come away by itself, which usually happens some four or five days after its insertion.

CHAPTER IX.

REMOVAL OF THE VERMIFORM APPENDIX.

THE operation here discussed concerns the removal of the diseased vermiform appendix during a quiescent period when all inflammatory symptoms have subsided.

In most cases the appendix has a distinct mesentery in which runs its artery—the termination of the ileo-colic. This mesentery (mesoappendix) when present is always derived from the posterior surface of that of the ileum.

In some instances the appendix is tied down to the iliac fossa. Its average length is 3½ inches, but it may be as short as half an inch or as long as six inches.

The most frequent positions for the appendix (which, of course, vary from time to time in the same individual) are (1) curved or coiling upwards and inwards behind the end of the ileum (Fig. 102, A); (2) over the brim of the pelvis and external iliac vessels, to which it may closely adhere (Fig. 102, c); (3) downwards and inwards behind and just above Poupart's ligament, and, more rarely (4), upwards along the outer margin of the cæcum and ascending colon (Fig. 102, B), occasionally reaching in front of the kidney up to the gall-bladder level; and (5) upwards directly behind the cæcum, by which it is entirely concealed (Fig. 102, D).

The appendix is supplied with blood by the posterior ileo-cæcal artery, a vessel which passes behind the end of the ileum to reach its destination. The artery to the appendix enters the mesoappendix and divides into three branches. The largest runs in the free edge of the meso-appendix and reaches the tip of the vermiform process. The other two reach the appendix at intervals of about half an inch.

The Incision.—The incision is about two inches in length, and is made obliquely across the line which joins the anterior superior iliac spine and the umbilicus. It is
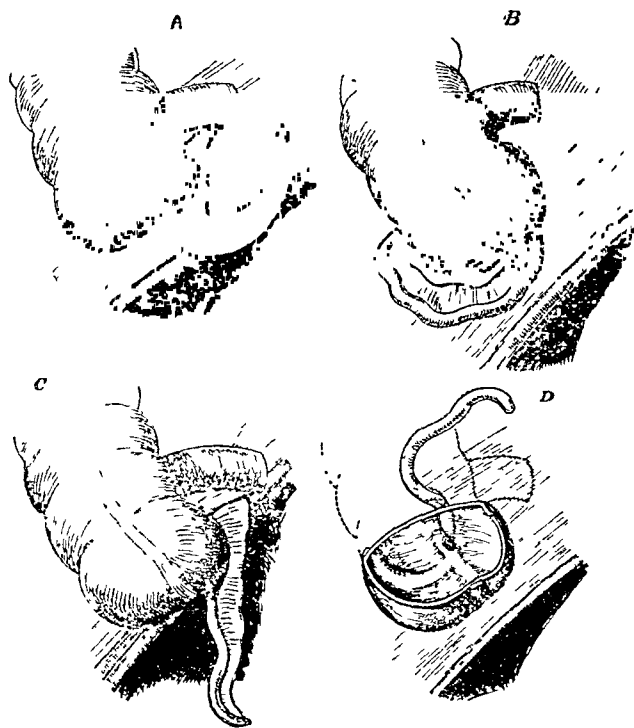
Fig. 102.—VARIOUS POSITIONS IN WHICH THE APPENDIX MAY BE FOUND.
(After Testut.)

A, Lying over the external iliac artery and curving upwards; B, Curving to the outer side of the cæcum with its tip directed upwards; C, Hanging down into the true pelvis; D, Lying behind and concealed by the cæcum. The mesoappendix is shown in A, B, and C.

placed over the semilunar line. The three muscles of the abdomen are clearly divided at the outer edge of the rectus muscle. These muscles in this position are all aponeurotic. The rectus sheath is not opened. The peritoneum is

divided with care, as the cæcum, ileum, or omentum may be adherent to the anterior abdominal wall at the point of the incision. The divided peritoneum on either side of the wound is neatly picked up with pressure forceps, and as these are drawn upon they act as retractors and facilitate the introduction of the fingers into the abdomen. Two fingers of the right hand are passed into the cavity, and the cæcal region is examined. In the female subject this examination should always include the right ovary.

Demonstrating the Appendix.—The cæcum is sought for and is gently drawn out of the wound by means of the two fingers. As a rule, this is readily done when there are no adhesions, and in such case the appendix is at once demonstrated. In a large proportion of cases, however, there are difficulties due to adhesions. The whole area should be well examined with the fingers, and the wound enlarged if necessary. The simplest way of finding the appendix is to identify the cæcum and the terminal part of the ileum, and where these two meet, the appendix will be found. The separation of the adherent appendix is often tedious. Care must be taken in clearing it of the iliac vein and of the ureter. Especial care is necessary when the ileum is closely involved in the adhesions. The adherent appendix may open by one or more ulcerations into the cæcum, colon, ileum, or rectum, and the apertures left in these viscera by the removal of the appendix must be carefully closed. The appendix is often adherent to the ovary or broad ligament, and occasionally it is attached to the bladder. In one case upon which I operated it opened into the interior of the bladder. The diseased structure may be buried in a mass of omentum, or may be closely united to the mesentery, or be buried in dense and almost cartilaginous tissue in the iliac fossa. It may extend upwards, and its tip be found under the liver. I have found it attached by its extremity to the left iliac fossa. A large proportion of the adhesions encountered are dealt with by the fingers. There must be no tearing, and no dragging of tissues apart with two pairs of dissecting forceps. The blunt dissector is often useful. All

resisting adhesions should be well defined and then cut
with scissors or a scalpel.   In all these preliminary mea-
sures the operator should observe the rule to keep close to
the appendix, and, above all, seek for its tip.   The free
end of the appendix is the key of the position when ad-
hesions are very troublesome.   When once that is found,
the difficulties are nearly over.

In many cases of difficulty I have divided the undis-
turbed peritoneum of the right iliac fossa well to the outer
side of the disturbed area, and by working along in the
retroperitoneal tissue have reached the adherent bowel, and
have readily detached it, stripping off the peritoneum with
it.   The operator should never drag upon adherent bowel,
especially upon adherent ileum.   The only structure upon
which considerable traction may safely be made is the
appendix.   This organ is apt to be much contorted, and is
often bent acutely upon itself.   The most difficult adhesions
are met with when the appendix is adherent to the floor
of the pelvis, and is possibly in communication with the
rectum.   A good electric light, a full retraction of the
margins of the wound, a very free incision, and the Tren-
delenburg position are necessary in these very troublesome
cases.

In dealing with such instances, the rule should always
be observed to keep throughout very close to the appendix,
which must be followed as a guide.

In detaching an adherent appendix an abscess cavity
may be discovered.   It will probably communicate with
the bowel.   It should be well sponged out, its walls scraped
away, and its cavity lightly dusted with a little iodoform.
In certain of these cases, but not in all, a gauze drain will
be needed.   A considerable amount of pale yellow, custard-
like material may be found about an adherent appendix.
It should be carefully scraped away, but no drain will in
such instances be required.   Caseous glands, if readily
isolated, should be removed whenever possible.

Treatment of the Pedicle.—As the appendix is
being isolated, care should be taken to demonstrate its
pedicle.   The pedicle represents the mesoappendix, or at

M*

least the source of the blood supply of the appendix. There
may be no mesoappendix. The appendix may derive its
blood supply direct from cæcal arteries, or direct from
adhesions. I have found it supplied apparently wholly
from adherent omentum. Sometimes the appendix is found
to be fibrous and shrunken, and in such case its blood
supply may be very small. I have removed such an
appendix without securing any vessels by ligature.

In an uncomplicated case the appendix and its mesen-
tery are readily brought out of the wound, and the rest of
the operation may be described as it would apply to such a
case. The mesoappendix is spread out. When the organ
is involved in the cæcal fossæ, this may not be readily
done until the folds of peritoneum which hide the meso-
appendix are neatly divided. These folds do not represent
adhesions. Close to the base of the appendix a gap will
always be noticed between the blood-vessels going to the
little tube. The mesoappendix is perforated at this gap,
and a silk ligature is passed through by means of a pair of
forceps. This ligature will suffice to secure the meso-
appendix when it is small. When it is wide the membrane
and its vessels should be secured by two silk ligatures.
The mesoappendix is now divided between the ligature or
ligatures and the appendix. Before it is cut, the meso-
appendix on the proximal side of the ligatures is secured
by pressure forceps to prevent it from slipping. The
divided mesoappendix may need a second ligature before
these forceps are detached and the stump is allowed to
drop back. When the appendix is adherent the adhesions
are dealt with similarly, and the organ about to be re-
moved is entirely freed from its blood-vessels.

Removal of the Appendix.—A ligature must be
applied at the very base of the appendix. This ligature
may be secured—if thought well—before the mesoappendix
is dealt with. The ligature is of silk, and is passed
through the gap between the vessels to which attention
has been directed. The peritoneum is divided with a
scalpel in a circular manner, at the point at which the
ligature will come. The serous membrane is just suffi-

ciently turned back to make room for the ligature. The
turning back of a cuff or flap or hood of peritoneum is use-
less. Such a cuff makes the poorest possible covering for
the stump of the appendix, and is probably absolutely
bloodless. The ligature is securely tied. The appendix is
then cut off with scissors close to the ligature. The scissors
thus used are at once put aside, and must not be employed
again until they have been freed of infection. The stump
of mucous membrane is trimmed down, and the instrument
or instruments used are put aside, as they will be infected.
The practice of applying the actual cautery or pure
carbolic acid to the appendix stump is to be condemned.
So long as the divided stump is exposed it is held in
position by the ligature which encircles it. The utmost
care must be taken that it touches nothing. If it acci-
dentally touches the parietal wound, the wound is quite
likely to give trouble later on. The stump is now seques-
trated by a series of Lembert's sutures, made of fine silk.
The sutures involve the cæcal wall around the stump of
the appendix. The stump is thus inturned and hidden
from view, and is perfectly secured. To cover the stump
with a hood or flap of peritoneum derived from the
appendix itself is not, I repeat, to cover it efficiently. Such
a flap is often impossible to provide. All ligatures are
cut short, and the cæcum is returned into the abdomen.
Occasionally the peritoneal coat of the cæcum is not avail-
able for helping to cover in the appendix stump. In such
an instance it is easy to find suitable serous membrane in
the vicinity.

It is important that the appendix should be divided as
close to the cæcum as is possible.

Closure of the Wound.—Small blunt hooks are
introduced into the ends of the wound, and by means of
them the edges of the wound are kept in perfect line, and
the parietes are withdrawn from the subjacent viscera. The
pressure forceps, which still hold the cut edges of the peri-
toneum, are removed by cutting away the little tag of
(damaged) peritoneum which they grip between their
blades. The peritoneum is united by a few very fine silk

sutures. The rest of the wound is closed by means of silk-worm-gut sutures, involving the skin and the muscles, which are neatly picked up in precise order.   In muscular subjects the muscles may be separately united by a series of buried sutures of kangaroo tendon.   In such cases there will there-fore be a line of sutures for the peritoneum, for the muscles, and for the skin respectively.

Modifications.—The chief modifications of the opera-tion relate to the incision employed.   It has been recom-mended that after incision of the external oblique parallel to its fibres the two deeper muscles should be traversed between their fibres without dividing them , in other words, the deeper part of the wound is made at right angles to the superficial one, the fibres of the muscles being drawn aside.   This method is clumsy and rather cramped, and will only suffice for uncomplicated cases.

CHAPTER X.

Operations on the Stomach.

The following operations upon the stomach will be described :—

1. Gastrostomy.
2. Gastrotomy.
3. Pyloro-plasty.
4. Gastro-jejunostomy.

I.—GASTROSTOMY.

This operation consists in establishing an artificial opening (*stoma*) in the stomach, through the parietes, with the purpose that the patient may be fed through the new "mouth."

Gastrostomy is carried out in cases of obstruction of the gullet, especially in such as are due to malignant disease.

Preparation of the Patient.—If the patient is no longer able to swallow, the strength should be supported by nutrient enemata. One such injection, containing an ounce of brandy, may be given just before the operation. There is no need to adopt any especial means for distending the stomach. The body should be well covered up with blankets, and the limbs surrounded by hot-water bottles.

Deep anæsthesia is not required. I have performed the operation when so small an amount of ether has been given that the patient, while complaining of no pain, has yet been dimly conscious of all the steps of the operation. It may be performed under eucaine or cocaine injections (2 per cent. solution of either). The quicker the operation can be carried out, within reason, the better.

Instruments Required.—Scalpels ; blunt-pointed bistoury ; dissecting forceps ; pressure forceps ; scissors ;

metal retractors ; blunt hooks ; curved needles and needle-holder ; sutures ; ligatures, etc. ; sharp tenotome to open the stomach ; rubber tube or catheter of about No. 10 English size.

1. **The Parietal Incision.**—The surgeon should endeavour to mark out the lower edge of the liver by percussion and palpation. The normal position of this edge is about two fingers' breadth below the ensiform cartilage. The liver, however, in the operation area may be found as high up as the level of the xiphoid cartilage, or as low down as the level of the ninth costal cartilage. In cases of stricture of the gullet, the organ is usually a little lower than normal, owing to the empty condition of the stomach and intestines.
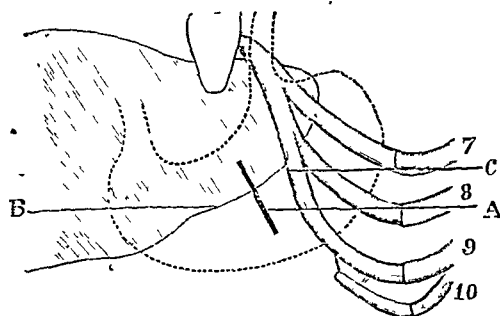
Fig. 103.—GASTROSTOMY.

A, Incision ; B, Margin of the liver ; C, Margin of the costal cartilages ; 7, 8, 9, and 10, Seventh to tenth costal cartilages.

The incision is oblique, is parallel to the margin of the left costal cartilages, and is about one inch from that margin. Its length is about two and a half inches, and may be modified according to the thickness of the parietes.

The centre of the incision should correspond to a point from three-fourths of an inch to one inch below the margin of the liver (Fig. 103).

The incision is carried through the tissues of the abdominal wall. The fibres of the external oblique muscle will be found to run almost at right angles to the line of the wound, and the fibres of the internal oblique to be nearly parallel with that line. The transversalis muscle will be cut transversely. The incision will probably cross the left semi-

lunar line, in which case some fibres of the rectus are exposed.

The peritoneum is reached, and is divided to the full length of the original wound.

2. **Exposure of the Stomach.**—Retractors are introduced into the wound, and search is made for the stomach. The liver will come into view, and below the margin of that organ the stomach may at once be detected. It is recognised by the smoothness and absolute opacity of its surface, by its faint pink colour, and by the thickness and stiffness of its wall, as demonstrated by pinching up a fold between the thumb and finger. To make the identification more certain, the relations of the viscus to adjacent structures, and especially to the liver, should be made out.

The colon has been mistaken for the stomach, and has been opened under the influence of that error. The stomach is usually contracted, and lies high up, under cover of the left lobe of the liver. In such case, the omentum or the transverse colon commonly presents. By means of a gauze sponge held in long pressure forceps, the colon may be thrust downwards into the abdomen, and the stomach thus brought into view ; or the surgeon may draw the colon downwards with his fingers. The omentum is more conveniently pushed away by means of the sponge, to the surface of which it readily attaches itself.

In any case of doubt the surgeon should follow the under-surface of the liver with his finger as far as the portal fissure. Thence he is conducted to the stomach by the gastro-hepatic omentum.

The stomach should be drawn to the wound, and the spot at which to open it must be determined upon

This spot should be as near to the lesser curvature as possible, and at a part free from large veins. It is most important, however, that the new opening should be so placed as to avoid any traction upon the stomach.

As soon as the situation of the "stoma" has been determined upon, the stomach wall may be lightly seized at the centre of the selected area by means of pressure forceps. By means of these forceps an elongated pouch of the organ

is drawn forwards and held in position while the sutures
are being introduced.

3. **Fixing of the Stomach.**—This is best effected
by means of fine silkworm-gut or silk sutures. The needles
should be of moderate size (about No. 5), and fully curved.

The stomach is
drawn well forward
into the wound, and
each needle is made
to take a good hold
of the gastric wall.
It should penetrate
all the coats except
the mucous. The
needle is then carried
through the perito-
neum, and ultimately
through the muscular
layers of the parietes
and the skin. In order
to make the inclusion
of the peritoneum
simple and certain, it
is as well to fix it

Fig. 104.—GASTROSTOMY.

A pouch of stomach (s) is drawn out and
fixed by sutures, two of which (1 and 1)
are shown passing through the abdominal
wall (w). These, although shown loose,
are securely knotted. A continuous suture
(2 and 2) is passed through the outer coats
of the stomach-pouch, which is then
incised at s.

on either side with
pressure forceps, by
means of which the
membrane can be
brought well into view
while the needles are
being passed.

The sutures
should be so inserted as to circumscribe an area on
the stomach about equal to a shilling-piece. From six to
ten sutures will suffice. It is as well to introduce several
of the main sutures before any are tied. The sutures
should take up enough of the stomach wall to secure a good
hold. The mucous coat must not be punctured, and each
stitch must be very securely tied. There should be no

dragging upon any part of the stomach. The sutures fix the base of the tubular pouch, which is drawn out into the wound. (Figs. 104 and 105.)

4. Opening of the Stomach.—It is usually well to open the stomach at once in order to feed the patient.

Should, however, the condition of the patient be sufficiently good to warrant three or four days' delay, the surgeon may decide to defer the opening for this time. There can be no doubt that this delay, made from a somewhat needless dread of causing peritonitis, has frequently caused death from exhaustion. Immediate opening according to the plan described is perfectly safe, and is to be advised. The essential thing is to make the incision through the stomach wall small and valvular. A great variety of
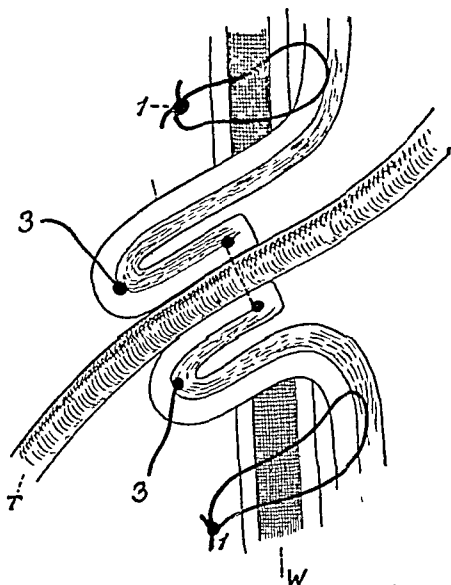
Fig. 105.— GASTROSTOMY.

The rubber tube (T) is introduced and fixed by tightening the suture shown in the previous figure. The pouch is then invaginated and a second continuous suture (3 and 3) maintains this condition.

NOTE.—The sutures 1 and 1, in both figures, should be more tightly tied.

methods have been devised with this object, but the following will be found as good as any. (*See* Figs. 104 and 105.)

A continuous silk suture is make to circumscribe a small circular area at the apex of the pouch, passing through the outer coats; before it is tied the stomach wall is incised with a tenotome within this area so as just to admit a No. 10

English rubber catheter, a few inches of which are then passed into the cavity. The stitch is then tied so as to fix the catheter without constricting its lumen, and the pouch invaginated for half an inch or so. A second continuous suture (passed into the rubber) is then introduced, as shown in Fig. 105, which prevents the tube from slipping and maintains a valvular fold of the whole stomach wall. The rubber tube can be attached when required to a glass funnel. Feeding with small quantities of milk, strong beef-tea, etc., is begun with caution as soon after the operation as thought advisable, the tube remaining in for several days, and being subsequently introduced from time to time.

If care be observed, there is practically no risk of any extravasation taking place during the feeding ; and even if it be assumed that the peritoneal cavity is not securely sealed, there is still no difficulty in preventing such an accident.

If it be determined to effect an opening into the stomach within a few hours of the first operation, the mode of suturing above described will be found to suffice. The attachment of the viscus to the parietes may in such case be rendered doubly secure by a series of fine silk sutures which are interposed between the main stitches, and which concern only the parietal peritoneum and the outer coats of the stomach.

The actual opening of the stomach is a very simple matter. It is painless, and no anæsthetic is required. Indeed, if the condition of the patient does not warrant a general anæsthetic being given, all the steps of the operation may be carried out under cocaine.

II.—GASTROTOMY.

This term is applied to the operation of opening the stomach for the purpose of removing a foreign body, or for exploration.

There is no need to attempt to bring about an artificial distension of the stomach before the operation.

The Operation.—The parietal incision may be made in the same position as is advised in gastrostomy, with this

modification—that it may be conveniently placed a little less close to the margins of the ribs.

If the foreign body can be distinctly felt through the parietes, then the incision may be made directly over it. The cut has been made in the left semilunar line. In removing unusually large foreign bodies, such as are represented by masses of hair, the incision may be conveniently made in the median line. The exact position of any metallic body can be ascertained beforehand by radiography.

The incision should be at first about two and a half inches in length. It may be enlarged subsequently as required.

The peritoneum is divided and the stomach sought for. If the contained foreign body be sharp-pointed, the manipulation of the stomach must be conducted with great care.

When the surgeon has determined upon the spot at which the opening into the stomach is to be made, two silkworm-gut sutures may be passed through the serous and muscular coats of the viscus, one on either side of the area selected for the incision. These sutures are allowed to form long loops, by means of which the stomach can be drawn forwards and held in place.

The stomach wall should be gently drawn well into the parietal wound, and before the opening is made the space between the viscus and the margins of the parietal incision must be plugged with sterilised gauze.

The incision into the stomach should be transverse to the long axis of the viscus—*i.e.*, in the line of the blood-vessels.

As soon as the organ has been opened, the forefinger is introduced and the position of the foreign body made out.

It should be so manipulated as to place it in the position best suited for ready removal.

Forceps will probably be required to effect the extraction. Care must be taken not to damage the wall of the stomach by careless manipulation, or by attempts to drag the foreign body through too small an incision.

The next step is the closure of the wound by suture. Fine silk should be used for the purpose. The divided

mucous membrane is first of all brought together by means of a continuous suture. This is best introduced by a small fully-curved needle, held in a needle-holder. The sutures must be well secured at each end, and must be tightly drawn throughout. The laxity of the gastric mucous membrane renders the application of this suture an easy matter.

The outer part of the gastric wound is closed by many points of Lembert's sutures. These are of fine silk, are introduced by means of an ordinary milliner's needle or a circular needle, and include both the serous and the muscular coats. The details of the suture have been dealt with in the section on Enterroraphy (page 327).

Any of the methods employed for suturing the intestine may be adapted to the stomach. It is desirable, however, in any case that a special line of suture should be employed to unite the edges of the mucous membrane. For the outer row there is nothing better than the interrupted Lembert suture.

The parts having been well cleansed, the gauze is removed, and also the guiding loops of silkworm-gut from the stomach wall.

The parietal incision is closed in the usual way.

III.—PYLORO-PLASTY.

By this term is understood a plastic operation, for the relief of fibrous stricture of the pylorus, in which no part of the intestinal wall is excised. It may be equally well carried out on any part of the intestine, but only when the stricture is ring-like, and does not involve much of the length of the gut. It is quite unsuited to cases of malignant disease. Its principle is simple. The narrowed part having been well defined, the stomach is opened to one side of the stricture, and a broad director (the old-fashioned hernia director is best) is passed through; on this the narrowed wall is completely divided into healthy tissue on the other side of the stricture. The longitudinal wound is then converted into a transverse one, by means of traction made with two hooks placed at the centre of either border.

A double row of stitches is next applied, the deeper sutures (which may well be continuous) going through mucous membrane and submucous tissue, the more superficial being the usual interrupted Lembert's stitches, which involve the serous and muscular coats. The hooks being withdrawn, an extra stitch is applied at either end, and the operation is completed by careful cleansing of the peritoneal surface of the pylorus and closure of the abdominal wound. The method will be readily understood by reference to Fig. 106. It has been largely employed for cicatricial stenosis following ulcer of the stomach, and occasionally when an active ulcer has been excised from the duodenum or pylorus with the view of preventing subsequent stricture. Pyloroplasty displaced stretching with the finger (Loreta's operation), and is certainly safer and more efficient, but on the permanency of its results much doubt has been thrown, since many cases of pyloric stricture in which it has been performed have required subsequent gastro-jejunostomy, although the patients were relieved for a time. It is easy to see why the operation may fail in its object, since the surgeon actually increases the amount of scar tissue; further, the

Fig. 106.—THE THREE STAGES OF PYLORO-PLASTY.

The upper figure shows the incision through constricted portion (B) from stomach (A) to duodenum (C). In the middle figure the wound is held open with hooks so as to become lozenge shaped. In the lower figure it is again converted into a linear wound and sutured up in the form shown. (Diagrammatic.)

cicatrix left by an ulcer of the pylorus is rarely a perfect ring, and the operation is useless for broad, irregular scars.

Hence, if the pylorus is much scarred or distorted it is safer to do a gastro-jejunostomy. If the surgeon attempts a pyloro-plastic operation and is dissatisfied with the immediate result, he may well perform the other operation at the same time, if the patient's condition allows of it.

IV.—GASTRO-JEJUNOSTOMY.

This operation consists in establishing a permanent communication between the stomach and the first coil of the jejunum just below the end of the duodenum. It was first proposed as a substitute for pyloric resection in cases of cancer of that part of the stomach.

The operation has been extended to cases of chronic ulcer of the stomach (1) when attended with recurring and severe hæmatemesis; (2) when stenosis has occurred at or near the pylorus due to cicatrisation of an ulcer; (3) when hour-glass contraction has developed from the same cause; (4) when symptoms of gastric ulcer have continued for some considerable time and have resisted careful dieting and medicinal treatment.

The object of the gastro-jejunostomy under these conditions is twofold—to relieve obstruction to the stomach by emptying its contents, and by giving rest to the organ to encourage healing of the ulcer.

In all cases of gastro-jejunostomy the first coil of small intestine below the fixed duodenum must be attached to the stomach. Thus, whatever method be employed, the surgeon must first find the termination of the duodenum, which is fixed in front of the aorta behind the transverse colon. The demonstration of the commencement of the jejunum is best effected by drawing the transverse colon upwards and by then passing the fingers along the under surface of the transverse mesocolon until the vertebral column is reached. Just to the left of the spine the terminal part of the duodenum will be discovered. This will lead to the jejunum, and traction upon the coil seized will demonstrate that it represents the very commencement of the jejunum.

It is important to favour, as far as is possible, the

contents of the stomach passing into the descending limb of the jejunal loop. For this reason the intestine should be so sutured that its axis may correspond with that of the stomach—*i.e.*, both running from left to right. Further, the direction of the loop secured should be obliquely downwards.

Instruments Required. — These are of a simple kind, and no special instruments are needed. Murphy's button or Mayo Robson's bone bobbin may be used at the discretion of the operator. Straight and curved needles threaded with fine sterilised silk should be prepared. A fine scalpel, dissecting and pressure forceps, and straight, fine-pointed scissors are essential. No clamps are required for either the stomach or the intestine.

1. **Anterior Gastro-jejunostomy by Suturing.** —The abdomen is opened in the middle line above the umbilicus, and the stomach region is explored. The great omentum is pushed to the left, the first coil of jejunum is identified in the manner described and is then drawn forwards in front of the transverse colon, so that it can be brought in contact with the stomach. The anterior wall of the latter is brought out of the wound, as well as the piece of jejunum, and both are packed round with sponges or gauze compresses. Care is taken that there is no strain put upon the jejunum when it is drawn into place. If the loop of jejunum be too short it acts as a strap across the transverse colon, and drags upon the stomach. The selected coil of jejunum is held by an assistant, whose fingers act as compressors. No clamps are needed. The stomach also is drawn into the parietal wound, and the point at which it is to be opened decided upon. A linear incision, one and a half inches in length, is now made through the outer coats only of both jejunum and stomach, the incisions being exactly opposite to each other. With a needle threaded with fine silk a continuous suture is passed parallel to the two incisions and posterior to them ; this is knotted at each end, and the two surfaces of stomach and jejunum are thus brought closely together. The free ends may be left long and secured with forceps. The suture should take a firm hold, going as deeply as the submucous

layer in each viscus. The intestine is now opened by completing the incision already begun, and by cutting through the mucous coat; this is best done with a tenotome and
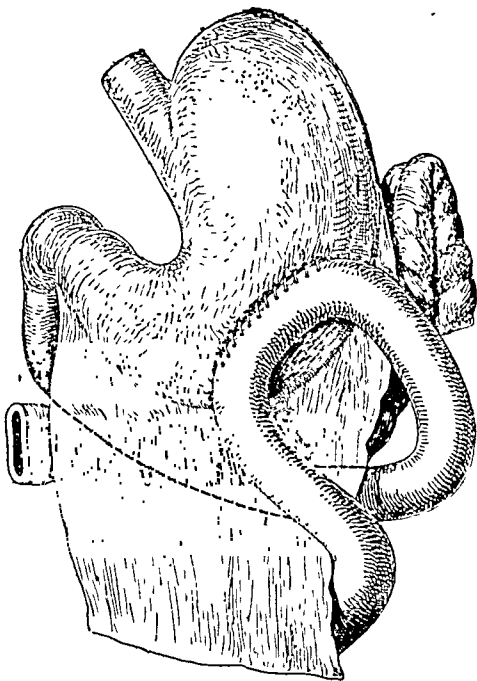
Fig. 107.—ANTERIOR GASTRO-JEJUNOSTOMY.
(From Hartmann's "Chirurgie Gastro-Intestinale.")

A loop of the jejunum is drawn in front of the great omentum and transverse colon, and is fixed to the anterior wall of the stomach. The opening between the two has been made, and the final continuous suture is shown drawing the outer coats of the two viscera together.

completed with scissors. The same step is carried out in the stomach, any gastric juice that escapes being at once mopped up with sponges. Any bleeding vessel should be seized with a Wells's forceps. A second line of continuous suture is carried through the posterior side of the opening

—*i.e.*, the side already dealt with—the needle traversing all the coats. It is often advisable to cut away with scissors the protruding edges of the mucous membrane. If a Robson's bobbin be employed it is now introduced, and the line of continuous suture carried around in front of it, being firmly secured at each end by a knot. It only remains to make a third line of suture through the outer coats in front of the opening—*i.e.*, to cover in the continuous suture just made. In cutting through the stomach and intestine walls some small arteries are sure to bleed, but they rarely require ligature, as clamping with Wells's forceps for a few minutes suffices to stop them. All sponges being counted and removed, the sides of the abdominal wound are held forward so that the stomach and the jejunum slip back, and the wound is closed in the usual manner.

The method of suturing employed in the above operation will perhaps be rendered clearer by recapitulation. The two linear incisions made through the outer coats only of stomach and jejunum should be of exactly the same length; they mark the size and position of the anastomotic opening. The first row of stitches, which take a firm hold of all but the mucous coats, fix the opposite surfaces of the two viscera together behind the linear incisions; it saves time to use the continuous suture, knotting it after every three or four insertions of the needle. Many operators employ interrupted sutures. The next step is the completion of the opening into both stomach and jejunum in front of the row just described. If the mucous membrane bulges, any redundant portion is cut away with scissors. The second row of sutures brings the edges of the opening into stomach and jejunum respectively into close contact all round; here also the continuous method is the best and most rapid. The third row, which is practically a continuous Lembert suture, is shown in Fig. 107; it traverses only the outer coats. Two or three additional Lembert's sutures at either end may be required to take off the strain on the others, and to prevent sharp kinking of the intestine.

2. **Posterior Gastro-jejunostomy by Suturing.** —This method differs from the preceding in the following

respects:—The transverse colon and the great oméntum
are turned upwards, and the under layer of the mesocolon
is exposed.   An aperture is made in the latter, avoiding
the branches of the superior mesenteric artery and vein.
Through this aperture the posterior wall of the stomach is
drawn, a sufficient area being exposed in which to make the
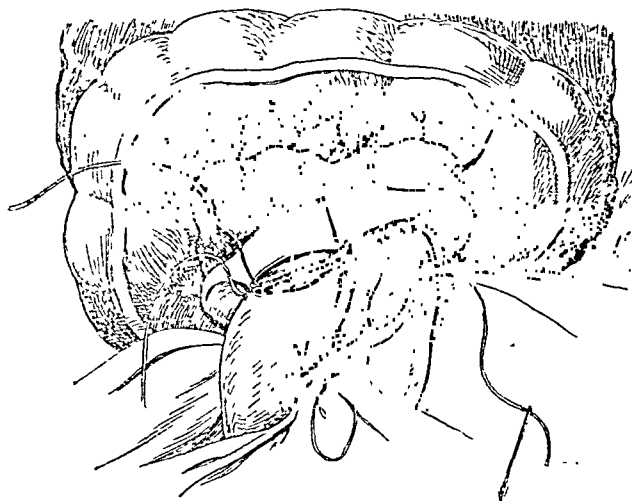
Fig. 108.—POSTERIOR GASTRO-JEJUNOSTOMY.

(From Hartmann's " Chirurgie Gastro-Intestinale.")

The transverse colon is raised and part of the stomach has been drawn
   through an aperture made in the transverse mesocolon.   The loop
   of the jejunum has been fixed to the stomach obliquely, the opening
   made between the two organs is being evenly secured all round by
   a continuous suture of silk.

anastomosis.   Two or three sutures are so applied as to fix
the edges of the opening in the mesocolon to the stomach
wall.   These sutures should only penetrate the outer coats
of the stomach.   The jejunum, having been picked up and
brought into position, is then sewn obliquely to the stomach
in precisely the same manner as already described (Fig. 108).
Robson's bobbin is often used to facilitate the suturing.

3. Gastro-jejunostomy by Murphy's Button.
—The chief points in this method have been referred to and
illustrated in the section on Suture of the Intestine
(page 324 *et seqq.*). Care should be taken to place the
heavier part of the button in the intestine, so that when it
works loose it may not fall into the stomach. It is, how-
ever, to some extent a matter of chance into which viscus
the button travels.

A few extra Lembert's sutures should be inserted to
hold the two viscera together in the neighbourhood of the
opening. This applies to all three methods described, as
they not only render the apposition more secure and the
chance of leakage less, but they also prevent kinking of
the intestine.

The one great advantage of the button is the rapidity
with which the operation can be performed. If the
stomach and jejunum are already in place in the wound,
the operation of gastro-jejunostomy can be completed in
some eight minutes.

The button may fall into the stomach and remain there
for weeks or months. I have known the button to be
passed *per anum* nine months after the operation. The
button has caused trouble from retention.

**Comments on and Modifications of the
Operation.**—At first the anterior method was alone used,
but posterior gastro-jejunostomy has come more and more
into favour, and by some surgeons is always employed. The
reasons given for the preference of the posterior method are
(1) the opening is lower down in the stomach ; (2) the
commencement of the jejunum is opened instead of a part of
the gut several inches from this point : hence regurgitation
is less common, and the stomach evacuates itself more
readily ; (3) there can be no interference with the transverse
colon by the jejunal loop, and no risk therefore of intestinal
obstruction.

On the other hand, anterior gastro-jejunostomy has
given excellent results in many cases, and it is somewhat
the easier to perform.

The question is hardly settled yet, but on the whole the

posterior method is to be advised whenever practicable. The extent of the cancer will often determine the surgeon's decision. As to whether Murphy's button or simple suturing should be employed, it may be noted that with the button the operation can be effected in less than half the time that suturing takes. Hence, if the patient is not in a condition to bear more than a short operation, the button should certainly be used.

On the other hand, suturing has given the larger percentage of recoveries ; it leaves no foreign body behind which may perhaps remain in the stomach, there is little or no tendency for the opening to contract (this has been repeatedly observed with the button), and many surgeons, after making a trial of the other method, have returned to simple suturing. The rapidity with which the latter can be performed largely depends on practice and the use of the continuous suture instead of interrupted stitches. In some of the earlier cases it is recorded that two, three, or even more hours were taken. A surgeon with experience of the operation need rarely spend an hour over the operation from the first step to the last.

CHAPTER XI.

OPERATIONS ON THE GALL BLADDER AND THE MAIN BILE-DUCTS.

I.—CHOLECYSTOTOMY.

By this operation is meant the making of an incision into the gall-bladder through a wound in the abdominal parietes.

Its chief indication is for the removal of gall-stones, whether impacted or not. It is also performed in cases of cholecystitis, in simple hydrops or distension with mucus of the gall-bladder—both conditions usually due to impacted gall-stone, but possibly to other causes, such as typhoid fever, hydatid cysts, or obstruction from growths at the transverse fissure.

Instruments required.—Scalpels; bistouries; dissecting, artery, and pressure forceps; long-bladed dissecting forceps; large pressure forceps for extensive adhesions —e.g., of omentum; rectangular retractors; spatulæ; blunt hooks; scissors; intestinal and other curved needles; needle-holder; sponge-holders; special scoops and forceps for dealing with the calculi (the scoops should be more flexible than the ordinary lithotomy ones); Lister's sinus forceps; long probe; aspirator, or trocar and cannula. A firm pillow or large sand-bag should be at hand.

The Operation.—The general management of the operation, the preparation of the patient, the position of the surgeon and his assistants, conform to the lines already laid down in dealing with abdominal section. Great assistance will be obtained in exposing the gall-bladder region by having a large sand-bag placed behind the patient's loins, so as to lift up and render convex the epigastrium.

The parietal incision is about three inches in length, and can be enlarged as required. It is best made vertically over the most prominent part of the tumour, when one

exists, or over the fundus of the gall-bladder when no swelling is evident.

It is easy to enlarge this vertical incision, which is placed in the linea semilunaris or the substance of the rectus muscle, by two nearly transverse shorter cuts at either end ; the upper one encroaches on the rectus muscle, the lower passes outwards, so that the whole becomes a sigmoid incision.

The peritoneum is opened, and the area of the operation is explored with the forefinger. The wound is enlarged as required. Intestine may protrude and hamper the surgeon's movements, or the omentum may be found in the way, or an enlarged liver may overshadow the operation region.

The gall-bladder and the cystic and common ducts should then be palpated (if necessary, the left index finger is passed through the foramen of Winslow), in order to ascertain the exact position of any calculi.

If the gall-bladder be found to be of great size, or very tense from over-distension, it should be carefully aspirated. The site of the needle puncture is protected by sponges, which are wedged in position. As the cyst is emptied, its wall is gradually and gently brought into the parietal wound. This is not always an easy matter, and as the cyst wall is often very thin, it must needs be handled with great gentleness.

Care must be taken that no fluid escapes into the peritoneal cavity. If the bladder be but slightly distended, its wall may be brought to the surface without previous aspiration.

The wall of the gall-bladder is best held and drawn forwards by means of pressure forceps. The amount of traction exercised must be very judiciously regulated. The wall of the gall-bladder is then opened by an incision made between the retaining forceps, all bleeding points are dealt with, and the forceps are readjusted so that the cyst may be drawn well forward, and held in position between the lips of the parietal wound. By means of properly-applied sponges the escape of fluid into the peritoneal cavity is prevented.

The finger introduced through the opening feels for the stones, notes their position, and ascertains the best means for removing them.   Loose stones may be removed with the finger, or by means of scoops or forceps of suitable size and pattern.   Long and slender scoops—aided by a finger outside the gall-bladder—are more useful than forceps.   If a stone be discovered impacted in the neck of the gall-bladder, it is well, before attempting its removal, to suture the margins of the wound in the gall-bladder to those of the wound in the parietes.

Inasmuch as the walls of the bladder are thin and often weak, the greatest care must be exercised in this, the most difficult part of the operation.

It is often well to suture only a part of the gall-bladder wound to the muscular wall, and to introduce the finger into the unsutured interval, so that it may supplement the action of forceps and scoops introduced into the interior of the viscus.   Before the suturing is carried out, all the sponges must be removed and counted.

In dislodging stones, Tait's special forceps are occasionally of service, and their movements within the bladder may be guided by the finger introduced into the abdomen, and placed against the outer wall of the cyst at the site of the impacted stone.

Sometimes the stone may be prised upwards by means of the finger so introduced.

If the calculus cannot be dislodged, then it may sometimes be very slowly and cautiously chipped into fragments by means of forceps, the action of which is controlled by the finger outside the gall-bladder.

In some cases the impacted stone has been broken up by means of forceps, the blades of which are padded with indiarubber tubing, applied to the stone outside, and therefore through the walls of the neck of the gall-bladder, or by pressure between finger and thumb.

The detritus which results from these procedures is got rid of by repeated washings.

Attempts to push the stone onwards through the duct by means of a probe or director have not met with much

success. The proceeding also is not free from risk, and is
to be condemned.

In some cases the surgeon has succeeded in dislodging
an impacted calculus in the cystic duct by means of fre-
quent syringing through the fistulous opening after the
operation had been completed.

It is, however, unsatisfactory to leave an impacted
calculus in either of the ducts ; it is better to remove it by
direct incision. The operator should do his utmost to
convince himself that all obstacles in the way of the bile-
flow are removed before completing the operation.

The treatment of such stones as are impacted so low
down in the duct as not to be reached from the gall-bladder
is dealt with in the succeeding section.

The operation is concluded by completing the suturing
of the gall-bladder to the edges of the peritoneum, fascia,
and muscular aponeurosis. The gall-bladder is held in
position while the sutures are being introduced.

The sand-bag should be removed from the lumbar region
before the suturing is performed.

The best suture in a straightforward case is an inter-
rupted suture of catgut, which includes the cyst wall, the
parietal peritoneum, and the muscular aponeurosis, but not
the skin or the muscles themselves. Silk sutures are apt to
give trouble later on. A drainage-tube is introduced into
the gall-bladder, the parts are cleared, and a simple
absorbent dressing capable of being frequently and readily
changed is applied.

The rest of the wound is closed by sutures of silkworm-
gut, two of which for extra safety may include the gall-bladder.

When the gall-bladder is so retracted that it cannot be
readily stitched to the parietes, a rubber drain should be
fixed in it by a purse-string suture (passing through the
wall of the tube) and then packed round with gauze.

II.—CHOLEDOCHOTOMY—INCISION INTO THE COMMON BILE-
DUCT.

The Operation.—The preparation of the patient,
the instruments, and the preliminary incision, etc., are the

same as for cholecystotomy (page 381). It is essential to
have a firm sand-bag behind the patient's loins, and after
the abdomen is opened the assistant should draw the liver
and costal edge well upwards so as to expose and straighten
out the biliary ducts. A vertical incision of the abdominal
wall through the semilunar line or right rectus muscle is
usually employed, to which it is easy to add a short
transverse one. Some surgeons advocate a nearly trans-
verse incision reaching towards the lumbar region. Such
a cut is somewhat more liable to be followed by a ventral
hernia.

Adhesions of the gall-bladder and liver to the stomach
or duodenum, if present, must be carefully separated, and
the gall-bladder is drawn upwards with the liver. If the
gall-bladder is felt to contain calculi it is opened and the
latter are evacuated. After the fluid has been let out the
opening should be guarded by sponges or gauze held in
place by an assistant whilst the operator traces down the
cystic and common bile-ducts. With finger and thumb he
ascertains the position and number of calculi present in
the common duct. A frequent place for impaction in the
duct is just above the orifice into the duodenum, where
the duct is somewhat dilated (forming the ampulla of
Vater). It will be remembered that the duodenal orifice
is the narrowest part of the duct, and that it is situated
at the inner and posterior aspect of the duodenum, just at
the angle between the second and third parts of the bowel.
Besides the ampulla of Vater there may be another dilated
portion of the common duct in which calculi are apt to
lodge, immediately below the junction of the cystic and
hepatic ducts. In tracing down the common bile-duct in
its lower half some assistance will be obtained by slightly
detaching and depressing the duodenum. The greatest
care is necessary in doing this, owing to the close relation
of the portal vein (behind the duct) and the hepatic artery
to its left. The pancreatico duodenal artery (a branch of
the hepatic) may give trouble. The lowest inch or more of
the duct is quite inaccessible from above ; it can only be
reached through the duodenum.

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In most cases of impacted calculi, however, the stones can be reached through an incision made in the axis of the duct where it lies between the layers of the gastro-hepatic omentum—*i.e.*, above the duodenum. The incision is usually made directly over the calculus, the duct being steadied and held forward with the left hand; the incision should be long enough to admit the index finger. The calculi are then extracted with a scoop, care being taken lest the rush of bile should soil the peritoneal cavity. The index finger is, if possible, introduced through the wound in the duct, and exploration made for any other stone.

The most difficult step of the operation is now to be carried out, that of suturing the small wound in the duct. Fine silk (No. 1) on a curved needle in a needle holder is employed, but the thinness of the duct may possibly prevent the wound from being perfectly closed, and it is essential, therefore, to provide for subsequent leakage. Small metal hammers have been employed for the purpose of introduction into the duct to facilitate suture, but no advantage whatever attends their use. After careful cleansing of the operation area and removal of all sponges, drainage is provided for by a rubber tube, one end of which is placed opposite the sutured duct; the tube is then lightly packed round with gauze, which is brought out of the wound in the abdominal wall at its lowest point. Some surgeons dispense with the tube, using only the gauze drain. The greater part of the abdominal wound is then closed with silkworm-gut sutures.

If a calculus be detected in the ampulla behind the duodenum the following course should be adopted:—The descending portion of the bowel should be incised, and its lumen immediately cleansed with sponges. Whilst the edges of the intestinal wound are held apart by an assistant with the aid of stitch retractors, the operator steadies the calculus with the fingers of the left hand, and incises the inner and posterior wall of the duodenum as closely as possible to the opening of the common bile-duct. As some museum specimens show, a large calculus may be found wedged in the actual orifice, and in such a case it may not,

be necessary to incise the posterior wall of the gut in order to liberate the stone.

Mayo Robson states that sutures need not be placed in the small posterior wound, but that the main incision into the duodenum should be accurately closed by a double row of stitches, one uniting the mucous membrane and the other the outer coats. The abdominal wound is sewn up in the usual manner, and drainage is unnecessary, unless doubt is felt as to perfect closure of the intestinal wound.

III.—CHOLECYSTENTEROSTOMY.

By this term is understood the establishment of a fistula between the gall-bladder and the intestine. The not less uncouth, but less precise, term of entero-cholecystotomy has also been applied to this operation.

The Operation.—The operation has been performed in many ways, and no settled practice can be said to be established. If possible, the communication should be made between the gall-bladder and the duodenum ; failing this, the opening should be placed on a loop of the jejunum or the colon. It may be done by suturing, or with the aid of the smallest size of Murphy's button. Mayo Robson and others have used his bone bobbin as an aid to suturing, but its advantage is doubtful.

The operation has been done in two or even three stages, but undoubtedly it is best to complete it in one.

The proceeding resembles so closely gastro-jejunostomy that no full description is called for. Murphy's button is particularly suited for establishing the anastomosis. The chief difficulty in performing the operation is perhaps the prevention of the escape of bile into the peritoneal cavity. Hence the space around the gall-bladder should be packed with sponges before incising that viscus, and the orifice of the button should be plugged with cotton-wool pledgets until the surgeon is ready to press the two halves together, when of course the plug should be removed. With good assistance the extravasation of bile can usually be prevented.

CHAPTER XII.

Operations on the Kidney.

The following operations will be described :—

1. Nephro-lithotomy, or incision of the kidney or its pelvis for stone.
2. Nephrectomy, or removal of the kidney.
3. Nephrorraphy, or fixation of a movable kidney.
4. Uretero-lithotomy.

I.—Nephro-lithotomy.

The value of the Röntgen rays as an aid to diagnosis is considerable. Unless the patient be very stout, this method will very usually indicate the presence of a stone, its size and position, and whether there is more than one.

This exposure to the rays need not be a long one in order to obtain satisfactory results; indeed, one of ten to fifteen seconds will give a better radiograph than a more prolonged one, as the blurring of shadow due to respiratory movement can be easily avoided with the short exposure.

A well-marked shadow of a renal calculus will enable the operator to mark its exact position, measuring from the iliac crest and spines.

The X-ray photographs are, however, not an infallible test for renal calculi. Very small stones may not be detected by them, nor larger ones in stout patients; and an abscess in the kidney may occasionally simulate calculus by causing a defined shadow. Tumours in or about the kidney may cause a faint shadow hardly to be compared with that caused by a stone.

Instruments required.—Scalpels; bistouries; dissecting, artery, and pressure forceps; two rectangular metal retractors. The following special instruments are used in

dealing with the stone:—A stout slender needle in a handle, or a hare-lip pin for sounding the calculus; long-bladed tenotome; suitable probes and scoops; steel director; the smallest-sized bladder-sound; Lister's sinus forceps; dressing forceps; gall-stone forceps. A small periosteal elevator may be useful in detaching some stones, and a No. 3 Duncan's uterine dilator has been recommended as a convenient sound.

<center>THE LUMBAR OPERATION.</center>

1. **Exposure of the Kidney.**—The patient lies upon the sound side, as near to the edge of the table as possible. The loin of the affected side is well exposed, and to widen the interval between the last rib and the crest of the ilium a narrow hard cushion or sand-bag should be placed under the loin of the sound side. This pillow may be a little in the way in the later stages of the operation, in which case it may be removed.

The surgeon stands by the patient's back, leaning over the trunk. An assistant stands on each side of him, to sponge and assist in retracting the wound. A third assistant is placed on the other side of the table, opposite to and facing the surgeon. His chief duty is to press the kidney towards the loin when the organ has been exposed.

The twelfth rib should be definitely recognised and well defined. It is occasionally absent or rudimentary, and then the pleural sac descends below the eleventh rib, which (unless the precaution is taken of counting the ribs from above) may be mistaken for the twelfth.

An oblique incision is made across the costo-iliac space. The cut commences above, about half an inch below the last rib and close to the outer border of the erector spinæ. It is continued downwards and forwards towards the crest of the ilium (Fig. 109). Its length must depend upon the space available, and upon the depth of the tissues of the loin. It will suffice if it be at first three inches in length, and it may be subsequently enlarged to four or five inches as required.

After dividing the skin, superficial fascia, and fat, the
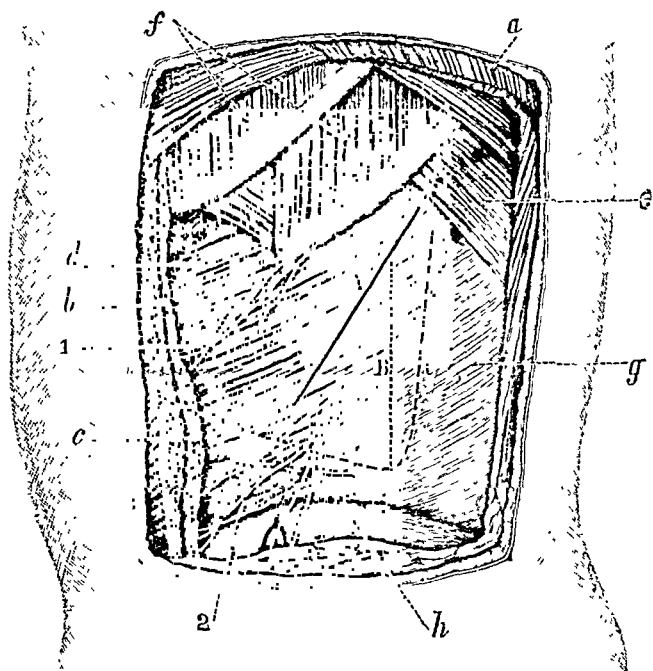
Fig. 109.—OPERATIONS ON THE KIDNEY.

A, Incision for exploration, for nephrotomy and nephro-lithotomy; B, Additional incision for nephrectomy; C. König's lumbo-abdominal incision for nephrectomy.

a, Latissimus dorsi; b, External oblique; c, Internal oblique; d, Transversalis; e, Serratus posticus inferior; f, Intercostals; g, Fascia lumborum over erector spinæ; h, Crest of ilium; 1, Intercostal nerve and artery; 2, Twelfth dorsal nerve and lumbar artery.

outer border of the latissimus dorsi and the hinder border of the external oblique muscles are exposed. The fibres of both are vertical, and they are divided to the full length of the skin incision. The sheath of the erector spinæ muscle should not be opened. The internal oblique muscle and the posterior aponeurosis of the transversalis muscle (fascia lumborum) are now laid bare. The fibres of the former

muscle run upwards and inwards. Piercing the fascia near the rib there may possibly be seen branches of the last dorsal nerve and last intercostal artery, and, nearer the iliac crest, the first lumbar nerve and a branch of the last lumbar artery. Both muscle and aponeurosis are divided to the full length of the wound. No director should be employed, and any bleeding points which give trouble may be ligatured, as pressure forceps are apt to be in the way. It is, however, very rarely that there is any need for a ligature at this stage. The anterior or outer edge of the quadratus lumborum, and the anterior layer of the fascia lumborum, are exposed. The latter is freely divided. The muscle may be severed if it encroaches on the field of the operation.

As each layer of tissue is divided, the several parts are retracted by means of broad, rectangular metal retractors.

The fascia transversalis is now reached and divided, when the perirenal fatty tissue is exposed.

The retractors are made to take up the whole of the severed structures down to the exposed fatty capsule, and the depths of the wound are laid open to the utmost.

The perirenal adipose tissue is now opened up with the forceps and finger, and the kidney is reached and laid bare. In order to bring it well into the field of the operation, an assistant should press the anterior wall of the abdomen with the palms of both hands towards the exposed loin, and endeavour, as it were, to force the kidney into the incision.

Through the free opening made in the perirenal fat the finger is introduced and the whole kidney systematically examined.

If long-standing inflammation has been present, the surrounding tissues will be confused, will be matted together, and will offer a more or less firm resistance to the exploring finger.

2. **Detection and Removal of the Stone.**—The use of the skiagraph has simplified both these procedures. It is possible that the exact position, size, and roughly the number of calculi present in the kidney (for they are often multiple) can be thus determined beforehand. With its

employment in skilled hands there is now less need to pierce the kidney in various directions with an exploring needle, or to disturb it from its connections and to bring it out into the wound. The operation is shortened, and the degree of renal injury materially decreased. It may possibly be said that the surgeon is rarely justified in exploring a kidney for stone unless the X-rays have given positive indication of its presence. It must, however, be again observed that a stone has been apparently indicated by a shadow in the skiagraph, and has been proved on exploration not to exist. On the other hand, stones of considerable size have not been indicated by skiagraphs taken by competent operators. Increased precision in the skiagraphy of the kidney is certainly to be expected. In the great majority of cases the calculi are found at the orifice of the ureter, in the pelvis (especially its lower segment), or in one of the calyces. The incision should be made through the posterior wall of the pelvis (Fig. 110, A).
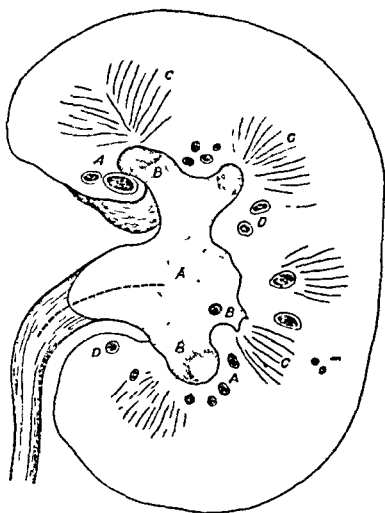
Fig. 110.—VERTICAL SECTION THROUGH THE LONG AXIS OF KIDNEY.

(*From a specimen in the London Hospital Museum.*)

The dotted line passing through the upper end of the ureter and into the pelvis indicates the best incision for reaching calculi in the latter or in one of the calyces (B). A section through the convexity of the cortex is seen to divide a number of arteries and veins of considerable size. A, D, Columns of Bertin and large vessels cut across; C, Pyramids of Malpighi.

The incision should always be long enough to admit the finger, and should be placed directly over the stone. It is

frequently advisable to encroach on the renal tissue, in which case the wound should radiate from the hilum parallel with the main vessels. It should not be forgotten that a branch of renal artery or vein is often present behind the pelvis, and care should be taken to avoid this if possible. The plan of entering the pelvis through a wound made through the outer border of the kidney is not to be commended. As shown in Fig. 110, such an incision must pass through a considerable thickness of the gland, and will probably divide several important vessels; in fact, the hæmorrhage following "bisection of the kidney" has in some cases necessitated nephrectomy, and even led to the patient's death.

The idea on which section through the cortex is based is that such wounds heal more readily than those made through the pelvis; but the latter, whether sutured or not, soon close up. As a general rule, the incision should run in the dotted line A in Fig. 110, or a continuation of it. Such an opening is well adapted for exploring the whole of the pelvis with finger or sound. Of course, if the skiagraph has revealed a small calculus near the cortex and far from the pelvis, the surgeon should cut down directly over it.

With regard to the *removal* of the stone, a pair of small lithotomy forceps, or a scoop aided by the surgeon's finger, will answer the best.

The object of the surgeon should be to remove, if possible, the calculus without breaking it, and with the infliction of the minimum of injury to the pelvis or the renal substance. If, however, the stone be large and irregularly branched, it may be found necessary to break it up into two or more fragments, and to remove them separately, so as to avoid undue laceration of the kidney. Such removal should be followed by a free irrigation of the part with warm sterilised water.

If the case and the operation be uncomplicated, the wound made in the pelvis of the kidney should be closed by a series of very fine silk sutures.

3. **Closure of the Wound.**—If the incision in the kidney be sutured, then the parietal wound may be entirely

N*

closed by silkworm-gut sutures passed deeply. If the renal wound be not sutured, then a full-sized drainage-tube should be introduced to the very bottom of the incision. It should be in contact with the wound in the kidney; around it should be packed some gauze, which will act as an additional drain.

The wound in the parietes is then closed in the usual way, and the drainage-tube secured in place by a suture.

II.—NEPHRECTOMY.

The operation of removing or excising the kidney has been performed for tumour of the kidney, for renal or ureteral fistula, and for disorganisation of the organ by injury, tuberculous disease, suppuration, or urinary infiltration.

Nephrectomy may be performed in two ways :—

1. By incision through the loin—lumbar nephrectomy.
2. By incision through the anterior abdominal parietes—abdominal nephrectomy.

1. LUMBAR NEPHRECTOMY.

Instruments required. — Scalpels; bistouries; dissecting, artery, and pressure forceps; large pressure or clamp forceps, straight and angular; broad metal rectangular retractors; blunt hooks; stout aneurysm needle in a long handle; pedicle needle; silk, kangaroo-tendon, and catgut ligatures.

The **position** of the patient, and of the operator and his assistants, is the same as has been already described (page 389). The hard pillow under the loin should be used, in order to extend the space between the last rib and the iliac crest.

Exposure and Isolation of the Kidney.— The incision made is the same as has been already described in the account of nephro-lithotomy (page 389).

When the organ is reached and has been superficially

examined, it will usually be found necessary to enlarge the original incision. This may be done in many ways.

The oblique incision may be extended to the full length admitted by the conformation of the individual. This incision will suffice for all cases in which the lumbar operation is allowable. If a greatly increased lumbar incision is called for, then, in my opinion, the lumbar operation is not permissible.

Morris advises that to the original cut be conjoined a second incision, running vertically downwards from the first, and starting from it about one inch in front of its posterior extremity (Fig. 109, B).

The kidney is exposed in the manner already described (page 391).

It is now necessary to examine it and separate it from its connections. Good broad rectangular retractors should be used, so as to expose the parts well, and an assistant should at the same time press the kidney into the wound by the hands applied over the front of the abdomen. If there have been no inflammation in the perinephric tissue, the separation of the kidney is easy.

The fatty tissue around the kidney can readily be detached by means of the index finger of one hand introduced into the depths of the wound, and swept round the organ in close contact with its capsule. In this manner the gland is readily enucleated and isolated.

When there has been much inflammation, as in cases of calculous or tuberculous · pyo-nephrosis, the tissue surrounding the kidney will be found condensed and adherent, and the enucleation of the organ will then be difficult, or in some few cases impossible. In such case the kidney should be enucleated from its thickened and firmly adherent capsule, and the latter left behind with the pedicle. In effecting this enucleation, a flat hernia director will be found to be of service.

Treatment of the Pedicle.—The kidney, having been freed, is drawn as far out of the wound as possible, and the pedicle is isolated with the fingers, and examined carefully. To obtain more room, the lower

ribs may be drawn forcibly upwards with a strong retractor.

The individual structures in the pedicle should be exposed and isolated as far as is possible by rapid dissection. The ureter is well isolated, and secured between two ligatures. The vessels are then secured separately, or in as small bundles as possible, the arteries first and the veins afterwards. Silk or kangaroo tendon is used to secure the pedicle, and it is conveniently passed by means of a stout aneurysm needle. The ligatures on the vessels should be applied as far from the kidney as is possible.

As each ligature is being drawn tight, all traction upon the pedicle must be taken off.

The pedicle is next divided with blunt-pointed scissors close to the hilum of the kidney.

The kidney is now removed.

The pedicle is examined. Any bleeding point detected should be at once seized with pressure forceps, and secured later. Such hæmorrhage may depend upon the existence of aberrant or abnormal branches that have escaped the ligatures on the pedicle.

The ureter is then examined. If it appears healthy it is left as it is, securely ligatured. If it be dilated and occupied with foul or tuberculous pus, then as much of the tube as can should be excised above a ligature applied as low down as possible.

The possible existence of abnormal veins and arteries must always be borne in mind. These vessels may escape the clamp or the ligature, and yet be severed when the kidney is removed. In more than one recorded case fatal hæmorrhage has resulted from this cause.

The wound in the parietes is now closed by sutures. These should be of silkworm gut, and should be passed deeply, so as to embrace the various layers of tissue divided.

2. ABDOMINAL NEPHRECTOMY.

The Operation.—The incision is vertical, is made in the semilunar line, is about four inches in length, and is

commenced just below the margin of the ribs. The centre of the incision will probably be about the level of the umbilicus. The abdomen is opened, the cut peritoneum on either side is picked up with pressure forceps, and when all bleeding has been checked the hand is introduced.

The following are now the steps of the operation :—

    A. Examination of the opposite kidney.
    B. Establishment of the coffer dam.
    C. Isolation and separation of the kidney.
    D. Isolation of the pedicle and demonstration of its
        component parts.
    E. Ligature of the pedicle.
    F. Removal of the kidney.
    G. Disposal of the ureter.

A. As a first measure the hand is passed across to the opposite side of the body, and the opposite kidney carefully examined. If this organ be found to be extensively diseased, or if it be discovered that the patient has but one kidney, then the nephrectomy must needs be at once abandoned.

The kidney on the affected side is now examined, its size is estimated, its general characters as regards mobility, consistence, etc., are ascertained, and the condition of its pedicle is demonstrated.

The small intestines are kept aside by slightly tilting the body to the opposite side.

The colon is made out, and is pushed towards the median line. The surgeon then incises the outer layer of the mesocolon vertically over the renal region. Into the rent thus made the fingers are introduced, and the kidney is laid bare.

B. Pressure forceps are made to grip the peritoneum on each side of this rent in the mesocolon. The forceps— some six on each side—are then lifted up and carry the two edges of the peritoneum with them, as one would lift up the mouth of a sac. The margins of the rent in the mesocolon are, indeed, drawn up until they reach the margins of the skin wound. The kidney lies exposed at the bottom of the peritoneal bag thus produced. It is within

this bag that the whole operation is carried out, the peritoneum being freely separated, so as to give plenty of room. The operation is thus carried out within a species of coffer dam. If the forceps be properly adjusted, the operation is extraperitoneal. The general peritoneal cavity is shut off. If the kidney contains an abscess and that abscess bursts during its removal, it bursts into the coffer dam, and is quite isolated. Any bleeding also is limited by the walls of the coffer dam, and must remain extra-peritoneal. I have never found any difficulty in main-taining this coffer dam intact during the whole of the operation. It has the advantage also of preventing any coil of small intestine from appearing in the operation area.

C. As soon as the coffer dam has been made secure, the kidney is exposed, and is well and thoroughly isolated all round. This separation is to a great extent effected by the fingers, which keep throughout very close to the capsule of the gland. Now and then the scissors are needed to divide resisting bands, and sometimes the scalpel is required. The most difficult part of the kidney to free is the upper end, and that should be dealt with last. Care must be taken to leave the suprarenal body behind. When the kidney is very adherent, this process of separation is very tedious. Free use of the scissors may be demanded. The chief rule is to keep always close to the kidney, and to be careful of the vessels when the hilum is reached. There is no objection to the leaving of parts of the capsule behind, but it should be avoided whenever possible.

D. When the kidney has been well and entirely freed, the next step is to free the pedicle. This must be done by pushing the peritoneum towards the median line. The pedicle must be isolated on all sides, in front, behind, above, and below. Some dissection will be needed to make this separation complete. The next step in the operation is the isolation of the component parts of the pedicle. This is done when the kidney has been drawn well outside the abdominal wound. The kidney is dragged upon and the pedicle displayed from all sides. The isolation of the ureter and chief vessels is effected by dissection with scalpel

and forceps, and with the forceps and the blunt dissector. On the right side the very close position of the vena cava must be borne in mind. Adhesions may render this part of the operation very difficult.

E. The pedicle is now tied in segments. The ureter is first isolated, and is at once severed between two strong silk ligatures. To the lower ligature a pair of pressure forceps are attached as a guide. The vessels of the pedicle are now tied separately or in small bundles by means of fine silk. The arteries are secured before the veins. An aneurysm needle is useful at this stage. The tension on the pedicle is relaxed as the ligatures are drawn tight. Before the pedicle is divided one or more clamps may be applied to the pedicle tissues on the proximal side of the ligatures.

F. The pedicle is now cut through with scissors. To prevent an escape of blood from the kidney, the vessels may be clamped on the kidney side of the intended line of section. The kidney is now free, and is removed. The surgeon then returns to the pedicle stump. He removes any clamp forceps which may be in position, and applies additional ligatures if necessary.

G. The surgeon now seeks for the divided ureter. If it be healthy, nothing remains but to cut the ligature on it short, and drop it back. If it be dilated or contain pus, as much of the tube as can be cut away should be removed. It should be ligatured, and the cut end exposed beyond the ligature should be very vigorously scraped with a Volkmann's spoon. It may be necessary to examine the ureter for a calculus, and to remove such calculus if found. I have met with no instance in which it appeared to be necessary to bring out the divided ends of the ureter through an incision in the loin. No circumstances would justify the bringing of the divided end of the ureter out at the anterior abdominal incision.

The cavity left by the removal of the kidney is well cleaned out, and if any septic matter is likely to have found its way into it, the whole cavity is well washed out with a weak and warm antiseptic solution. When the operator has convinced himself that all oozing has ceased, and that

the operation area is absolutely clean, the wound in the parietes may be closed in the usual way, and a suitable dressing applied.   No drainage is required.

If, however, any septic matter has escaped into the cavity left by the removal of the kidney, then drainage should be employed.   The drainage-tube is best carried through the loin at a convenient spot close to the anterior or outer edge of the quadratus lumborum muscle.

There is no need to close by sutures the rent made in the peritoneum.

III.—NEPHRORRAPHY.

This operation is practised in exceptional cases of floating, movable, or wandering kidney, in which the organ is the seat of severe and spasmodic attacks of pain, due to torsion of the pedicle.   It is occasionally also employed in special cases in which there is more or less continuous discomfort, and in which all other measures—such as the use of a carefully fitted abdominal belt—have failed.

The operation was at one time somewhat indiscriminately employed.   It should be restricted to the exceptional case.

The Operation.—The kidney is exposed through the loin in the manner already described (page 389). When reached, it is well forced into the wound by an assistant, who presses upon it with both hands applied over the anterior abdominal wall.   The fatty capsule is well opened up.   Often very considerable difficulty will be experienced in fixing an unusually mobile organ.

The posterior surface of the kidney in its capsule is thoroughly exposed and brought into the wound.   A curved needle charged with fairly thick kangaroo tendon is passed through the muscular and aponeurotic edge at the upper end of the wound, and then, carefully avoiding the peritoneum, is made to pierce the upper part of the kidney. The needle dips into the kidney substance for half an inch or less, and emerges from one to two inches from its point of entrance, so that the ligature gets a wide hold on the kidney.   The needle is then passed through the opposite

edge of muscle, and the loop is held in a pair of pressure forceps. A second and third suture is similarly introduced below the first one, traversing the middle and lower parts of the kidneys. Four and even five such sutures may sometimes be employed. The patient is then turned almost into the supine position and the sutures are knotted securely one by one, without employing such force as would risk their cutting through. The kidney tissue is very soft, and the sutures are readily made to cut through unless tied very gently. If necessary, one or more buried sutures of tendon may be employed to close the wound in the muscles still further.

There is no necessity to introduce the sutures deeply into the renal cortex, and there should be no risk of passing one into the pelvis or one of the calyces. The superficial part of the wound is closed with silkworm-gut. Drainage is not required.

IV.—URETERO-LITHOTOMY.

A calculus may be impacted at the junction of the renal pelvis with its ureter, at the vesical orifice, or at any point between these two. Hence no fixed rules can be laid down for its extraction. In the majority of cases the stone should be cut down upon in the lumber region through an incision made as for nephrotomy, commencing at the angle between the erector spinæ and the last rib, and passing downwards to the iliac crest. The Röntgen rays should always have been used beforehand, and the position of the calculus ascertained as far as possible. The lower end of the kidney and the pelvis having been identified, the calculus is sought by palpation. If it can be detected in or near the renal pelvis, the latter is incised, care being taken to avoid any aberrant renal vessels (it is quite common to find one or more branches of the renal vessels passing *behind* the upper end of the ureter). A gush of urine ensues, and the finger, being introduced, will perhaps succeed in extracting the stone aided by pressure from below with the left hand. A small lithotomy scoop or forceps such as are used in

cholecystotomy may be required, and the forceps should have a secure grip to prevent the stone from slipping out of their grasp.

If the calculus be fixed in the ureter too low down to allow of its being pushed upwards into the pelvis, the ureter should be incised in its long axis directly over the stone, which may be reached from the loin as low as the upper part of the iliac fossa.

If, however, it is previously known that a calculus is impacted within a few inches of the bladder, an incision should be made similar to that used for ligature of the common iliac artery. This incision is made just above and parallel to the outer half of Poupart's ligament, curving upwards and slightly inwards when it reaches the level of the anterior superior spine. The abdominal muscles and transversalis fascia are divided in this incision until the subperitoneal fatty layer is reached ; the peritoneum is then gradually pushed inwards until the ureter is reached as it crosses the bifurcation of the common iliac artery. Its identification will probably be rendered easy by its distension with urine ; the distended part may measure two inches or more in diameter. Whilst his assistant presses aside the peritoneum, the operator opens the ureter longitudinally, and after the urine has escaped into a sponge held ready for it, he passes a bent pair of forceps down to grasp the stone. If the patient be a woman, the manipulation will be much aided by the index finger of the opposite hand in the vagina pushing upwards and steadying the stone. The stone is usually elongated, with its long axis, of course, in the line of the ureter. Should the patient be thin, the ureter will probably be reached with ease, and the extraction of the stone may present no difficulty. Far otherwise is it if the patient be stout, for the search for a small calculus at the depth of some eight inches of fat from the surface, whilst venous oozing is continuous, may tax the resources and patience of the operator to the utmost.

It is needless to say that under such unfavourable circumstances no attempt should be made to suture the wound

in the renal pelvis or ureter ; but in ordinary cases this
may be done with success, and such suturing should be
employed as a routine measure.   In any case due pro-
vision should be made for drainage of the wound.

In order to expose the greater part of the ureter
from the renal pelvis down to near the bladder, a very
long incision (lumbo-ilio-inguinal) is advocated by Mr.
H. Morris.   This incision commences under the last rib,
passes forwards and downwards across the ilio-costal space,
curves round the iliac crest one inch to the inner side
of the anterior superior spine, runs parallel with Poupart's
ligament, and ends nearly at the external abdominal
ring.

The peritoneum must on no account be opened, and
the spermatic vessels in the male, the ovarian in the female,
must be carefully avoided.   If an impacted stone be
detected it should, if possible, be pushed upwards into the
dilated portion of the ureter, which is then incised.   After
the removal of the stone, the incision in the ureter is closed
by sutures.

Part IX.

OPERATIONS ON HERNIA.

CHAPTER I.

Operation for Strangulated Hernia.

Instruments required.—A scalpel and hernia knife; dissecting forceps; fine-toothed forceps; pressure and artery forceps; blunt-pointed bistoury; hernia directors; blunt hooks; needles; scissors; sutures. In the event of its being necessary to resect a portion of the prolapsed intestine, clamps, intestinal needles, and suitable sutures should be at hand.

The hernia knife should be as simple as possible, and should have a short cutting edge. "Guarded knives," "herniotomes," and other complex instruments for dividing the stricture, should be avoided.

1. **Exposure and Opening of the Sac.**—An incision is made over the neck of the sac, and as a rule in the long axis of the tumour. This incision should be placed as far from the genital region as possible; thus in the case of inguinal hernia it should not encroach on the scrotum. The various layers between the integument and the sac are divided by clean and precise cuts that involve the whole length of the incision. Any vessels that are liable to be divided are secured with pressure forceps.

There is no need to use a director in dividing the tissues which cover the sac, and that dangerous instrument can very well at this stage be dispensed with.

It is needless to say that the various precise anatomical coverings of the sac cannot be identified as they are divided.

The subcutaneous tissue can of course be recognised, and in the inguinal region the intercolumnar fascia and the cremasteric fascia can often be made out; but beyond this the surgeon will be but little reminded of the coverings which are so elaborately displayed in the dissecting-room.

The sac, when well exposed, has usually a distinct capsule-like outline, its walls are tense, and when they are thin, the blood-stained fluid contained therein, or the purple gut, may give to the structure a bluish aspect. In a thick-walled sac, this somewhat characteristic bluish tint may be entirely absent.

The sac is best identified by the fingers, rather than by the eyes. As the hernia is laid bare, the surgeon should from time to time pinch up the coverings yet left undivided between the finger and thumb, and estimate their thickness.

Any attempt to demonstrate the sac by counting the supposed anatomical layers that are divided in exposing it is almost sure to be fallacious.

The sac, having been identified, is well exposed, and its neck is well cleared.

Before opening the sac, the operator pinches up a minute portion of the wall between his finger and thumb, in order to estimate its thickness and to demonstrate that it is clear from attachments to the contents of the sac. A like fold in the sac wall is then picked up by dissecting forceps and opened by means of a scalpel, the blade of which is held nearly flat. The operator pulls the little fold of sac away from the bowel as he makes the division. When once an opening is made, it is readily enlarged by means of a blunt-pointed bistoury, or blunt-pointed scissors. The sac should be cleanly opened, and not torn open. The operation up to this point should be carried out by careful incisions, and not by tearing.

2. Division of the Stricture, and the Treatment of the Contents of the Sac.—The exposed bowel is carefully examined and its treatment determined upon. The less it is handled the better. If it be in a condition suitable for reduction, the next step will be to divide the stricture. The neck of the sac is examined

with the point of the left forefinger, and the density of the
stricture and the best point for introducing the hernia knife
is determined upon. The finger must be used gently. There
must be no attempt made to dilate the stricture with the
finger, or to force the finger through the constricted aper-
ture. The part of the bowel that usually suffers most in
strangulated hernia is the part directly embraced by the
stricture, and this is the part that will be crushed and
bruised if persistent attempts be made to force the finger
into the stricture.

The forefinger lies with the nail towards the bowel, and
the most the surgeon does is to make clear a point at which
the hernia knife can be inserted. The finger is the best
director : the hernia knife is passed along it with the blade
flat against the finger. The point of the knife at last
reaches the pulp of the finger that is pressed against the
stricture, while the nail lies against the bowel. The point
of the knife is passed, still on the flat, beyond the finger and
into the ring. It is then turned with its edge towards the
stricture, and by a slight movement of the blade the stric-
ture is divided.

The left forefinger, or in case of a tight neck to the sac
the little finger, acts throughout as a guide. It is retained
in position after the knife has been withdrawn, and is then
employed to ascertain that the division of the stricture has
been sufficiently complete.

The knife is used with a gentle sawing movement ; and
with regard to the edge, it is better for it to be too blunt
than too sharp.

In many instances the finger cannot be entirely relied
upon, and a director must be used. This especially applies
to cases where the neck is deeply placed, where the stricture
is narrow and tight, and where a place for the introduction
of the hernia knife cannot be made out by the forefinger.

The choice of the director employed must depend upon
the habit of the operator and the nature of the case in hand.
It is introduced with the right hand, guided by the left
forefinger, and must be most carefully manipulated. The
left forefinger and the director are employed in exactly the

same manner and relation as the forefinger and the knife.

When once the director has been passed through the stricture, and is in place, it is held in position with the left hand, while the hernia knife is used in the right.

The knife must be cautiously introduced. It is possible for the bowel to overlap the director and the knife, and to be cut by the movement of the blade. When the bowel is in danger, it should be pressed aside by the assistant with his finger or a small sponge held in a holder. It is well to have but a very limited cutting edge, and to see that the whole of the cutting edge is well within the stricture before the division is attempted.

After the knife has been withdrawn, the stricture may be further dilated with the director, which is forced against the divided fibres, and therefore away from the bowel.

It should be a rule to endeavour to make as slight a division of the stricture as possible, such a division as will allow of the gut being reduced, and no more.

The loop of bowel should now be gently drawn down and the constricted part examined, since it is here that the injurious effects of the strangulation may be most manifest.

The next step is to reduce the gut, the fibrous and muscular structures around the hernial orifice being relaxed as far as possible. In inguinal and femoral ruptures this is effected by flexing the thigh upon the pelvis. An attempt is then made to squeeze the bowel by a kind of kneading movement with the thumb and fingers through the opening.

The manipulation must be of the gentlest, and the surgeon must be prepared to exercise considerable patience. If the coil will not return by pressure applied at one extremity, it may yield by pressure applied at the other end of the loop.

In some cases of difficulty, the reduction is rendered easier if the margin of the hernial orifice is held up by means of a small blunt hook introduced into it, or by two pressure forceps grasping the opened sac and straightening its neck. This especially applies to large inguinal herniæ.

In other cases more bowel may be drawn down from the abdomen, and the reduction may then be directed in the line in which the withdrawal of the intestine appears to be the more easily effected.

If the bowel be much distended, that part nearest to the ring can often be emptied of some portion of its contents by judicious manipulation.

Any flakes of lymph that may be disturbed in handling the gut should be washed away with warm sterile water.

After the reduction the finger should be passed through the ring into the abdomen, to make sure that all is clear. The sac is now washed out.

If any omentum exists in the hernia, it must be dealt with as its condition demands.

If it appears healthy, is small in amount, and is quite free from adhesions, it may be reduced. Nothing better can be done for it. In the majority of cases, however, it will need to be removed. It will be found to be altered in structure, to be inflamed, or to be matted into a granular kind of mass, or to be adherent.

Small portions may be ligatured *en masse* with one catgut ligature, and then cut off. Larger portions are most conveniently dealt with by passing a series of loops of catgut by means of an aneurysm needle, each loop enclosing one or more omental vessels. Fine catgut may be used, but each loop must be securely knotted, a treble knot being the safest. When the expanded portion of the omentum has been excised below the ligatures the latter should be inspected and cut short before returning the stump into the abdomen. The risk of a ligature slipping is avoided by making each include only a small part of the omental neck.

It is well to remember that, however large the protruded mass may be, it will have a comparatively slender neck.

The reduction of the stump of the omentum should be in every case complete. It should be returned quite free into the abdomen. No part should be left either in the sac or in its neck.

3. Treatment of the Sac and Closure of the Wound.—In very severe cases, in which the patient

is already much exhausted, and in which it is desirable to complete the operation with as little delay as possible, the sac may be left as it is, and the wound closed.

In cases of a less extreme degree, in which no complication exists that opposes the measure, the sac may be dealt with according to one of the methods of " radical cure."

In the majority of cases the simpler the measure the better.

The wound having been well washed out, and any redundant skin removed, the margins of the incision are united by sutures.

4. **Treatment of Complications.**—A. *When the Intestine is Adherent to the Sac.*—Adhesions of the bowel to omentum are readily enough dealt with.   The omentum, if it cannot be peeled off from the intestine, is cut away with scissors until only the slightest trace of it is left still attached to the gut, which can then be reduced.

Adhesions of the bowel to the sac may, when slight and recent, be broken down with the finger or a flat director; when, however, they are of old standing and extensive, their treatment becomes a matter of some difficulty.   These examples of extensive and firm adhesions are for the most part met with in old umbilical or scrotal herniæ of large size, which have been for many years irreducible, and have perhaps been more than once inflamed.

The "breaking-down" of such adhesions must be a matter of infinite care, as the bowel is, as a rule, more readily torn than is the wall of the sac.

Many of the adhesions can be divided with scissors or a scalpel, and some may be torn through after partial division.

B. *When the Gut is Gangrenous.*—Much has been written upon the subject of the treatment of gangrenous intestine in hernia, and very remarkable differences of opinion have been expressed upon the question.   It would be out of place to enter into a discussion of this subject, or to consider minutely the physical signs that may distinguish intestine which is gangrenous from that which may still recover.

If the bowel, when exposed, be in what may be termed a doubtful condition, it had better be reduced into the abdomen. It is in a more favourable position for recovery within the peritoneal cavity than within the inflamed sac. Before replacement, the parts concerned should be well washed with an antiseptic solution. Such a coil of bowel seldom travels far from the hernial ring. The sac should be left open, and a drainage-tube of large size be introduced. If the gut at a later period gives way, it will do so gradually; and as adhesions are rapidly formed, the intestinal contents will escape along the course of the open sac. Whatever theoretical objections may exist to this procedure, practice has shown that it may be safely carried out, assuming that it applies to bowel which is not actually gangrenous, but in a condition which may be termed doubtful. It is remarkable to what an extent these loops of " doubtful " intestine recover.

If the bowel, when exposed, be found to be gangrenous, two courses are open to the operator :—

(1) The stricture may be divided, and the gangrenous bowel resected.

In carrying out the resection, either an artificial anus may be established, which can be closed by a subsequent operation, or the divided ends of the gut may be at once united and returned into the abdomen. The union may be effected by means of a double row of sutures, or by Murphy's button ; by preference the former, if the patient be in a condition to bear the lengthy operation.

(2) The sac having been well opened up and well washed out with an antiseptic solution, the bowel is left *in situ* after having been incised. The parts are well dusted with iodoform, and means are taken to provide the most efficient drainage. Several surgeons of eminence advise that in these cases the stricture should be divided, and that the gut should be left *in situ*, having been first secured by means of two or three silk stitches passed through the serous and muscular coats, and then fastened to the skin. The objection to this plan is that the abdominal cavity is opened up and exposed to infection from

the putrid contents of the sac. A barrier of lymph will have already shut off the gangrenous segment, and this protective barrier is broken down. Should the bowel be in a doubtful condition, the plan last described may be advisable; but when it is actually gangrenous, it does not appear to have much to recommend it. It has been urged, also, that if the stricture be not divided, the intestinal obstruction is not relieved. This argument in favour of dividing the stricture is, however, not supported by experience. It will be found that when gangrene has set in, nearly all tension is taken off from the parts, especially when the gas and œdematous effusion which attend the process are evacuated by an incision; and it is usual to observe fæcal matter at once escape when the putrid bowel is incised.

If there be no immediate escape of the intestinal con-· tents, such discharge will take place as soon as the swelling of the parts has subsided, as a result of the incision of the gut.

c. *When the Intestine is Wounded.*—The bowel may be accidentally wounded when too rash a division of the superficial parts is made, when adhesions exist between the gut and the sac, when the altered gut is mistaken for the sac, or when the loop of bowel comes into accidental contact with the edge of the hernia knife as it is being passed through the stricture.

The opening made should in each case be closed by means of Lembert's suture, the loop of gut should be returned into the abdomen, and if the wound has been extensive, it will be as well to leave the sac open, and to introduce a large drainage-tube, in case the intestine should give way at a later period.

THE OPERATION AS APPLIED TO PARTICULAR HERNIÆ.

1. **Inguinal Hernia.**—The patient having been prepared in the manner already described, an incision is made over the centre of the tumour, and in the long axis of the tumour, and is so arranged that the centre of the wound

will about correspond to the external ring (Fig. 111). It
is rarely necessary to encroach upon the scrotum, and the
incision need not come below the pubis ; it will then be
easy to keep the wound aseptic and protected by the
dressing. The cut may at first be some inch and a half
in length, and may be enlarged subsequently if required.

The sac is exposed ; the only layers of tissue which
will probably be recognised are the intercolumnar and the
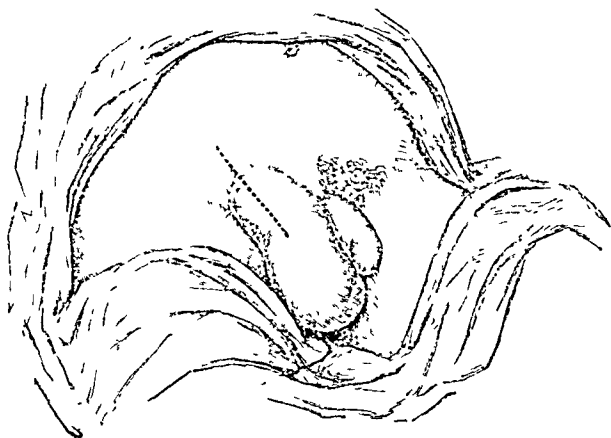
Fig. 111.—INCISION FOR INGUINAL HERNIA.

cremasteric. The superficial external pudic artery will
probably be severed in dividing the subcutaneous tissues.

The sac is opened and the contents are dealt with in
the manner already described (page 405). In dividing the
stricture the knife should be made to cut in a direction
upwards—*i.e.* parallel with the median line.

To relax the parts about the inguinal ring as the bowel
is being reduced, the thigh should be a little flexed upon
the abdomen, and should be at the same time a little
adducted and rotated in.

In the case of a large scrotal hernia, any redundant
skin may be excised.

After the wound has been closed, the dressing is

applied, and is fixed in place by means of a spica bandage, which should be applied while the thigh is in the position of flexion.

When the limb is brought again into the extended posture the bandage is drawn tight.

2. **Femoral Hernia.**—The usual preparations having been made, a vertical incision is made along the inner side of the tumour, and is so placed that the centre of the cut will about correspond with the upper border of the saphenous opening. The wound will be at first about one inch and a half in length, and may be enlarged as required. The exact position and extent of the wound must depend on the individual case, but the further from the genitals it is placed the more easily will asepsis be obtained.

As a rule, no vessels of any note are divided in exposing the sac.

The operation is completed in the manner already described (page 405).

The stricture is usually formed by the margin of Gimbernat's ligament, and should be divided by cutting upwards and inwards—*i.e.*, towards the median line.

In reducing the bowel the thigh should be a little flexed, adducted, and rotated in.

A similar spica is applied to that used in inguinal hernia.

3. **Umbilical Hernia.**—In addition to the instruments already enumerated, the surgeon should be provided with ivory spatulæ, curved needles in handles, and large curved needles.

The patient is prepared as for an abdominal section, and the general disposition of those concerned in the operation should be the same as is observed in that procedure. The surgeon will always stand to the patient's right.

Nearly the whole of the skin involved in the protrusion is now marked off by means of an elliptical incision, the long axis of which will correspond to the median line. The incision will extend, indeed, on to the median line above and below the swelling; and as it crosses the tumour it will

traverse its wall on either side, but a little way from its base. The incision is such as would be made to remove a pendulous tumour of like dimensions situated in the midst of comparatively lax tissues.

The first incision is only skin deep, and the hernia must be moved from one side to the other with the left hand as occasion requires.

The surgeon now deepens the wound on one side of the base of the mass, and, by cutting through the subcutaneous tissue, aims at exposing the aponeurosis of the abdomen a little way beyond—*i.e.*, to one side of the neck of the rupture. To effect this, such skin as covers the base of the protrusion is turned back. When once the aponeurosis is reached, it is followed all round the stalk of the tumour by deepening the incision. When this has been done, the hernia, covered by perfectly undisturbed skin, will be entirely isolated from all the tissues outside the abdomen, and will be attached only by its neck. The neck must be well cleared, and the aponeurosis which bounds it, and which, therefore, forms the margin of the hernial orifice, must be laid quite bare.

The sac may now be opened at any convenient spot where it can be proved to be free from adhesion to its contents. The contents are exposed and are dealt with in the manner already described. Adhesions are divided, the bowel is freed, and, if in sound condition, is reduced into the abdomen. Before this can be done, the hernial orifice will need to be divided; and this can be effected by enlarging the opening above and below the neck of the sac in the median line with a probe-pointed bistoury. This division may be extraperitoneal. After the gut has been replaced, the omentum is excised, or dealt with in a manner suited to its condition.

The omentum is best ligatured and cut through where it emerges from the abdomen, without regard to its adhesions to the sac. By this method considerable time is saved in the operation.

The sac is at last emptied, and the hole leading into the abdomen is then plugged with a large Turkey sponge secured in a holder.

The next step is to excise the whole of the sac and its coverings, including the elliptical portion of the skin, down to the level of the aponeurosis. This may be effected with the scalpel at one sweep.

The margins of the ring are now freshened, as in plastic operations involving the skin, and the opening in the aponeurotic part of the abdominal parieties is closed by sutures. These buried sutures should be of silk or of strong kangaroo tendon. They may be introduced on a curved needle in a needle holder. Before they are inserted, the sponge should be removed and be replaced by the end of an ivory spatula, which will serve to protect the intestines from injury. As many sutures as possible should be introduced before any are tied. They must be closely placed—four to six to the inch—and must include the whole thickness of the aponeurosis and the peritoneum.

The operation is concluded by suturing the skin and subcutaneous tissues with silkworm-gut. The wound is entirely closed, and no drainage tube is required. The dressing of the wound and its subsequent treatment are conducted upon the lines observed in other abdominal operations.

CHAPTER II.

OPERATIONS FOR THE RADICAL CURE OF HERNIA.

Instruments required.—Blunt hooks; scissors; scalpels; pressure forceps; dissecting and fine pointed forceps; curved and straight needles; needle-holders, etc. Special mounted needles (of the pattern designed by Sir W. Macewen and others) are sometimes used, but they are usually made too clumsy and blunt at the points. A simple long needle mounted on a holder and sharp-pointed is useful. It should be slightly curved on the flat. For introducing the deep stitches, ordinary fully-curved needles will be found more convenient than any special form. It is most important that all sutures, whether they are to be buried or not, should have been rendered perfectly aseptic. For the deep sutures there is nothing to equal kangaroo tendon which has been preserved in 1 and 20 alcoholic solution of carbolic acid, and which before the operation is placed in cold sterile water to remove the antiseptic agent.

The Incision, etc.—The whole of the pubic region having been shaved and carefully disinfected beforehand, the skin over the inguinal canal is finally cleansed with an alcoholic solution of carbolic acid or biniodide of mercury, and then dried with sterilised pads. The penis and scrotum, thighs, and upper part of abdomen are protected with dry sterilised towels. Only the region just above Poupart's ligament requires to be exposed, as the incision is placed here whether the hernia may have descended to the bottom of the scrotum or not.

The operator feels for the pubic spine, identifies the external ring and Poupart's ligament, and then proceeds to make a linear incision which commences over the ring and runs for three or four inches parallel to and above the ligament (Fig. 112).

This incision goes straight down to the external oblique aponeurosis, which is the first landmark recognised ; when it is exposed, the handle of the scalpel should be used to clear both the external ring and the aponeurosis upwards
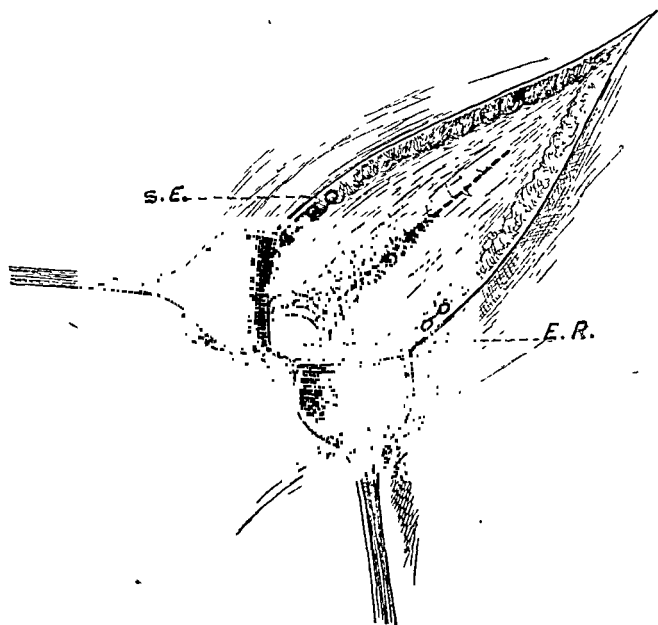
Fig. 112.—RADICAL CURE OF HERNIA.

Incision over the left inguinal canal, ending below at E.R, the external ring. The weak portion of the aponeurosis is shaded ; the dotted line passes through this and indicates the cut made in the external oblique. S.E, Superficial epigastric vessels divided.

and downwards. In making this incision the superficial epigastric vessels and perhaps the superficial external pubic ones are divided, and should be at once secured with pressure forceps. These forceps should be held up by the assistant, as they serve as excellent retractors. Towards the end of the operation these small arteries and veins may

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be tied with catgut. In the great majority of cases the surgeon will incise the external oblique from one inguinal ring to the other, but whether this be done or not the cremasteric covering of the cord must be opened in order that the hernial sac may be reached. The sac is almost invariably found in front of the main structures in the cord, and, if empty, is distinguished by its white colour and well-defined edge from the connective tissue, etc., which surrounds it.

Method of Dealing with the Hernial Sac.—Two rules may be laid down: First, the contents of the sac must be wholly returned within the abdomen; second, the sac itself must be isolated right up to the internal ring. With regard to the contents, but little difficulty is usually met with in reducing intestine. In some exceptional cases of hernia of the cæcum or sigmoid flexure it may be necessary to dissect off adhesions to the posterior wall; but any small intestine is readily returned and prevented from protruding during the further step by sponge pressure. Occasionally the bladder projects into the hernial sac on its inner side, and special caution should be exercised lest it should be opened during the dissection—an accident which has happened in many cases.

Much more frequently the omentum gives trouble, owing to its adhesions or to its local hypertrophy.* It is essential that the omentum should be freed completely, and, if necessary, the protruding part is excised after securing its neck by several catgut ligatures. This should be done slowly and carefully, as in several instances death has followed the slipping of a ligature from the omental pedicle. The omentum should never be used to plug the hernial orifice (as recommended by some writers), since it not only favours recurrence, but may cause trouble by dragging down the transverse colon and stomach, or even lead to fatal intestinal obstruction.

* In dealing with adherent omentum it is often best to disregard the lower adhesions, and commence with the pedicle, where they will probably be absent. After ligature and division of this the omentum in the sac can be removed in one piece with the latter. This method is still more useful in umbilical hernia.

It is further important that the ligatures should not be placed too close to the large intestine, and that they should be thoroughly aseptic. Peritonitis has been known to result from the application of an infected ligature to the omental stump. Fine catgut, very securely knotted, answers best, and when the operator is satisfied that there is no bleeding from any vessel in the omental pedicle the latter is gently pushed up into the abdomen. After its return it is a good precaution to introduce a small sponge on a holder through the internal ring to make sure that there is no hæmorrhage.

The sac is now isolated from the cord; the higher up this is commenced the easier it is to effect. The spermatic vessels and the vas deferens are, as a rule, spread out around the sac, especially on its posterior aspect. In congenital herniæ they may project into its interior covered by a fold of peritoneum. Their separation is mainly accomplished with forceps, which are used to peel off the vessels without actually taking hold of them. The left index finger introduced into the sac will facilitate the procedure. The separation is effected transversely to the neck of the sac. When once this is done, the constituents of the cord can be readily detached in an upward and downward direction.

If the hernia be of the congenital form the lower end of the sac is sewn up with fine catgut so as to complete the tunica vaginalis. In an adult, if the sac extends down into the scrotum it is unnecessary to follow it there. The upper part only should be isolated and divided. In many cases, however, the whole sac is freed up to the internal ring by blunt dissection, the position of the ring being recognised by the deep epigastric artery and vein. The procedure introduced by Macewen of folding up the sac and making a pad, which is kept in place by a deep suture, is rarely employed, and does not appear to have any special advantage. One of the following methods is to be adopted in preference :—

1. The sac is ligatured as high as possible with catgut or kangaroo tendon, which for security may be passed

through its neck and tied with the Staffordshire knot. The
ends are cut short, and the stump left to itself.

2. The sac being ligatured in the manner described,
each end of the ligature is successively threaded on a
mounted needle with its eye close to the point. Guided
by the left index finger, the needle is made to transfix the
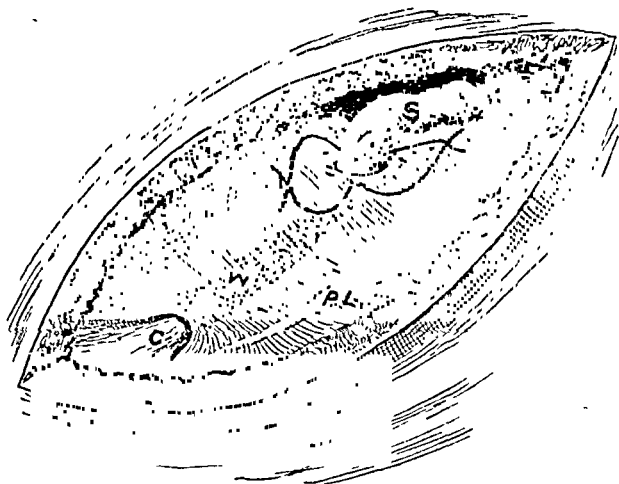
Fig. 113.—RADICAL CURE OF HERNIA.

P.L., *Poupart's Ligament ;* O, *Spermatic cord. The stump of the sac* (s)
has been twisted and brought through a small opening made in the
muscles, where it is fixed by two deep sutures which are shown not
yet secured. The dotted area w indicates the thin portion of external
oblique aponeurosis which is divided if the canal be opened up.

transversalis and oblique muscles at two adjacent points at
least an inch above and to the outer side of the internal
ring. The threads, being drawn through on the superficial
aspect of the muscles, are now tied together so as to fix
the stump away from the inguinal canal. It will be
understood that the stump of peritoneum is not itself
drawn through the abdominal wall, but simply anchored
behind the latter, well away from the site of its former
protrusion.

3. The sac is held by pressure forceps and twisted on its long axis several times. The left index finger is passed upwards along the canal under the oblique and transversalis muscles, and a small incision made over its tip so as to allow a pair of forceps to be introduced from without inwards. The forceps are then opened and made to grasp the twisted sac, which is now drawn through the opening and securely fixed there by tendon stitches, which maintain the torsion (Fig. 113). It will be understood that the opening is placed well to the outer side and above the internal ring, that it is completely plugged by the twisted sac, and that the superfluous portion of the latter is cut away.

Unless the sac be unusually thick, this method is a very good one, and no recurrence ever takes place at the site of the small incision. The advantage of torsion in tightening up the peritoneum in this region has been especially pointed out by Sir Charles Ball of Dublin and Prof. Kocher of Berne.

4. In a few cases where the abdominal opening of the hernia is exceptionally wide, it may be advisable to sew it up with catgut instead of ligaturing or twisting the sac. This applies to ventral as well as to ordinary inguinal herniæ.

It is doubtful which of the first three methods given above is really the best, though personally we incline to the third, which includes torsion with high ligation for most cases, the chief exception being those in which the sac is so thick that it would be difficult to bring it through any small incision in the muscles.

Methods of Narrowing or Obliterating the Inguinal Canal.—Three methods will be described :—

1. Suturing the conjoined muscles to Poupart's ligament with replacement of the cord in the inguinal canal (Bassini's method).
2. Suturing the conjoined muscles to Poupart's ligament in front of the cord.
3. Complete obliteration of the inguinal canal.

In young children and adults in whom the inguinal canal has not been stretched by the frequent descent of a hernia—in other words, those in whom the parts are normal but for the presence of a congenital pouch of peritoneum— it is only necessary to deal with the sac in the manner described.

But in most cases where the radical cure is required it is advisable that the canal should be narrowed, and considerable changes in the methods of doing this have been made during the last ten or fifteen years. Formerly narrowing sutures were placed in the external ring alone, or with the addition of one or more which drew the conjoined tendon over towards the external oblique in front of and above the cord. To place these stitches correctly without exposing the deep muscles by slitting up the external oblique is a difficult matter, and the external ring is not really at fault in the production of a hernia ; it is, moreover, easy to narrow this opening too much with injurious effects upon the circulation through the cord. Of the three methods described, one includes the obliteration of the inguinal canal, the other two its narrowing at the upper end. It is both unnecessary and impossible to describe the host of modifications to which various surgeons' names have been attached.

1. *Method of Suturing the Conjoined Muscles to Poupart's Ligament with Replacement of the Cord in the Inguinal Canal.*—The aponeurosis of the external oblique is divided parallel to and above Poupart's ligament from the external ring to a point just above the internal ring. The cord is thus exposed surrounded by the cremasteric fibres, and the lower edge of the internal oblique muscle is clearly defined as it arches over the cord. The latter is then lifted mainly by blunt dissection from its bed, and at the same time the inner surface of the external oblique is defined and cleared both upwards and downwards, so that the strong band which forms Poupart's ligament is thoroughly exposed. The cremasteric layer is then opened so that the sac can be isolated and dealt with by one of the methods already described. Any surrounding fat may

well be removed, bu   'ess a varicocele exists, it is un-
necessary (as sometimes advised) to excise any of the veins
of the cord.   The cord is lifted up by two blunt hooks,
which are held by an assistant, and a series of interrupted
sutures of kangaroo
tendon is passed
through the lower
edge of the muscles
that go to form the
conjoined tendon,
and through the
inner edge of
Poupart's ligament
(Fig. 114). These
sutures are intro-
duced in a series
before any one of
them is tied. They
all lie beneath the
cord, and care
must be taken in
passing the curved
needle through
Poupart's ligament
that the iliac ves-
sels are not inter-
fered with.   By
securing these
sutures the internal
ring is narrowed.
The cord is now
replaced and the

Fig. 114.—RADICAL CURE OF HERNIA.

The aponeurosis of the external oblique has been divided. Three deep sutures (1, 2, 3) have been passed through I.O, the internal oblique, the transversalis, and Poupart's ligament. E.O, External oblique. The spermatic cord has been purposely omitted in this figure for the sake of clearness.

two edges of the cut external oblique are sewn together again
over the cord.   The ilio-hypogastric nerve must be avoided,
or, if preferred, it may be resected.   Finally, any subcutaneous
vessels which have been held in pressure forceps are
ligatured with fine catgut if necessary, and the wound is
closed in the ordinary manner with silkworm-gut sutures
without drainage.   A sterilised dressing is applied with

firm pressure, whilst the thigh is kept somewhat flexed.
It is rarely necessary to remove the spica bandage until the
tenth day, when the silkworm-gut sutures are removed and
a pad and bandage reapplied.   At the end of a fortnight
to three weeks the patient may be allowed up.   No truss
should be worn.

The method just described is not applicable to all cases.
In some the conjoined tendon is poorly developed, and in
some it can only be fixed to Poupart's ligament with
difficulty.   This implies subsequent tension and strain when
the patient uses his abdominal muscles.

*2. Method of Suturing the Conjoined Muscles to Pou-
part's Ligament in front of the Cord.*—By the previously
described method the surgeon narrows the upper opening
of the inguinal canal to any desired degree, but it is not
suitable for all cases, owing to the difficulties of bringing
down the internal oblique and transversalis muscles to
Poupart's ligament without undue tension.   The following
method avoids this ; it consists in "restoring the valvular
action" of these muscles by giving them a lower attach-
ment in front of the cord.   It is, in fact, Sir William
Macewen's original operation performed after the canal
has been laid open, and has therefore the advantage that
the sutures are passed with greater ease and certainty.
It is unnecessary to open up the external ring, though
whether this is done or not is a matter of small importance.

It is assumed that the external oblique has been divided
parallel to Poupart's ligament, that the lower edge of the
conjoined muscles where they arch over the cord has been
thoroughly exposed and isolated, and that the hernial sac
has been dealt with in the manner described above.   The
lower portion of the external oblique, including the external
pillar of the ring, is now held up with forceps, and a
curved needle carrying a strong piece of kangaroo tendon
(some surgeons use stout catgut, others silk) is passed from
without inwards through the external oblique just above
Poupart's ligament.   The needle is then made to traverse
the lower edge of the conjoined muscles from within—*i.e.,*
from their abdominal aspect—and back again, a quarter

of an inch nearer the middle line.   It is now passed through the external oblique the same distance from the original point of entrance.

Thus the so-called mattress suture is completed; the needle is released, and the two ends of the suture are held in a pressure forceps until ready for tying.   A second and a third loop of suture are then introduced in the same way, all of them passing in front of the cord, which need not be raised from its normal position in the canal.   Two points must be attended to—the ilio-inguinal nerve must not be included in any of the sutures (as it is very apt to be), and the suture material must be perfectly aseptic and not too thick.

The sutures are now tied and the lower edge of the muscles is thus brought down in front of the cord.   It only remains to sew up the divided external oblique.

A modification of this method, especially suitable for inguinal hernia in women, consists in passing a series of interrupted tendon or silk sutures through the lower portion of the external oblique, then through the conjoined muscles from within outwards, and finally through the upper part of the external oblique.   These sutures should be placed very near to each other, and as the external ring is approached the external oblique only should be included.

It is presumed that aseptic healing occurs.   Under these circumstances the buried sutures may be relied on to last long enough for all purposes, whether kangaroo tendon or silk has been used.

3. *Complete Obliteration of the Inguinal Canal.*—The cord being freed from the internal ring down to the os pubis, and the sac having been dealt with, the cord is held forward by blunt hooks, and a series of sutures is passed through the edges of the external oblique, the internal oblique, and the transversalis on the one side, and the lower part of the external oblique on the other side (Fig 115).   The lowest sutures will pass only through the former pillars of the ring. Room must be left at the upper end for the cord, which is now placed on the outer surface of the external oblique.   If necessary, one or two stitches may be passed above the new

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'aperture for the cord, but it is a mistake to make this unduly narrow, as the circulation of the testis will be interfered with. There is no reason for the proposal to excise any of the spermatic veins unless there be a coincident varicocele.
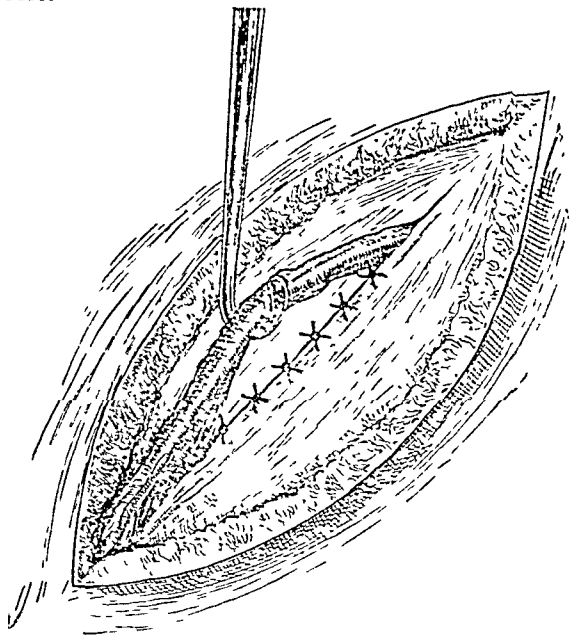
Fig. 115.—RADICAL CURE OF INGUINAL HERNIA. (*After Kelly.*)

Complete obliteration of inguinal canal by sutures. The spermatic cord is held forward on a hook.

The stitches should be placed close together, and whilst some advocate silk as the material, we strongly recommend kangaroo tendon. When the latter material is used and due care taken as to asepsis, it is possible to perform a hundred successive operations for radical cure without the slightest trouble arising from a single stitch. The same can hardly be said if silk be used.

A word of caution is necessary as to the deep epigastric

vessels.   In passing the uppermost sutures it has happened that the epigastric artery has been wounded and most serious hæmorrhage ensued, even necessitating ligature of the external iliac artery.   It should also be noted that the lowest suture is not placed close to the os pubis, as the pillars cannot here be approximated, nor is it necessary to attempt it.

In the female the round ligament may be disregarded and the canal obliterated completely.

When raising the cord in the male by blunt hooks in order to pass the sutures, it should be remembered that occasionally thrombosis of the spermatic veins has been produced—an accident which may also follow undue narrowing of the aperture made for the cord.   Beyond the formation of a hard lump above the testicle and possibly œdema of the scrotum, little harm is likely to result, but in one or two cases symptoms of pulmonary embolism have been recorded.   Hence the operator should be careful to avoid undue traction on the spermatic vessels during the operation, and also to allow sufficient room for their passage through the abdominal wall.

After the sutures have been tied and cut short, and the cord has been replaced over them, three or four fine catgut ligatures are usually required for the superficial vessels. The skin wound is then sewn up with silkworm gut.

In **congenital hernia** the sac is first isolated from the cord, and this is by far the most difficult part of the operation, since not only is the sac wall thin, but the spermatic vessels and the vas closely adhere to it, either projecting into or being spread out around it.

Nevertheless, by patient dissection with toothed forceps and fine probe, it is always possible to separate the sac from all the constituents of the cord at some point, and when once this has been effected it is easy to continue the separation upwards and downwards.   In young children the vas deferens is a very slender structure, and may easily be divided if the knife be used during the separation of the sac.   The latter process must be complete—*i.e.* no peritoneal covering must be left on the cord, otherwise

recurrence of the hernia will probably take place. The isolated sac should now be divided transversely about an inch above the testicle. The lower part is formed into a tunica vaginalis. The upper is pulled down as far as possible, and dealt with exactly as the sac of an acquired hernia, additional precautions being necessary to clear the cord at the internal abdominal ring. It is freed of its connections, and placed as a pad on the abdominal aspect of the circumference of the internal ring, or, better, twisted up and securely fixed by tendon or catgut sutures in a small aperture made in the oblique muscles above and to the outer side of the internal ring.

Dressing and After-treatment.—A drainage-tube is never required. A light dressing of sterilised gauze is kept in place by a spica bandage, firmly applied when the thigh is slightly flexed at the hip-joint. A piece of macintosh or other protective is secured over the whole in the case of young children, to avoid the chance of accidental contamination of the dressings from without. The dressing is not disturbed for from ten to fourteen days, when the skin sutures are removed, unless a continuous catgut stitch has been employed, which will not need removal.

RADICAL CURE OF FEMORAL HERNIA.

The sac is first completely isolated up to the femoral ring. Should it contain adherent omentum, the latter is separated and returned within the abdomen. The neck of the sac is then transfixed by a mounted needle threaded with kangaroo tendon or stout catgut, the needle is withdrawn, and the ligature securely tied around the sac, which is then cut away below it. Each end of the ligature is then threaded on the handled needle, which is introduced from below upwards through the abdominal wall just above Poupart's ligament, and the two ends are knotted together in front of the external oblique, so as to draw the pedicle away from the femoral ring.

If the neck of the sac has but little fat around it and is therefore of slender proportion, it may conveniently be

twisted and fixed by sutures in a small aperture made just above Poupart's ligament. In either case the passage of the ligatures or of the twisted sac through the lower edge of the abdominal wall is rendered easy and safe by the introduction of the left index finger into the femoral ring to act as a guide.

As a rule, especially if the femoral ring be large, an attempt should be made to narrow the latter by sutures passing through Poupart's and Hey's ligaments in front, and the fascia over the pectineus muscle behind. During the introduction of these sutures the femoral vein on the outer side is carefully guarded with the finger. Some surgeons use two or more interrupted sutures; others employ the purse-string method.

Many other plans have been proposed for dealing with the femoral ring. Thus a small flap of the external oblique aponeurosis has been turned down and sewn to the pectineal fascia, or a flap of the pectineus muscle has been turned up and sewn to Poupart's ligament. The muscle, however, makes an unsatisfactory kind of shutter, and probably atrophies in a short time. The conjoined tendon is also sometimes drawn down and sewn to the pectineal fascia.

In most cases of femoral hernia, dealing thoroughly with the neck of the sac as high up as possible in the manner described suffices to produce a radical cure; but, provided that the ring can be narrowed by deep sutures without undue tension on the latter, it is certainly an additional safeguard to employ them.

Part X.

OPERATIONS ON THE BLADDER.

CHAPTER I.

LATERAL AND MEDIAN LITHOTOMY.

I.—LATERAL LITHOTOMY.

THE operations of lateral and median lithotomy, which at one time held so important a place among surgical procedures, have now almost vanished from modern practice, and have been replaced by lithotrity or litholapaxy to a very great extent.

Instruments employed.—The fewer the instruments employed, and the simpler they are, the better.

The following list represents the full series of instruments required:—Grooved staff; lithotomy knife; probe-ended bistoury; lithotomy forceps and scoop, lithotomy tube; sound; probe; pressure forceps; syringe; anklets. To these may be added a petticoated tube or tampon and a lithotrite.

Placing of the Patient in Position, and Introduction of the Staff.—The anæsthetic is administered, and as soon as the patient is insensible the anklets and wristbands may be applied. The patient is now brought down to the end of the table until the buttocks are projecting over the actual foot of the table. In this position, and while the legs are hanging towards the floor, the staff may be introduced. As soon as it is in place, the knees are very carefully brought up towards the chest, and the patient is

fixed in the lithotomy position. It is very undesirable .to introduce the staff while the patient is lying flat upon the table, and before any step has been taken to bring him into position. The rough movements necessary may cause the staff to damage the bladder or the urethra. If the staff be introduced as above advised, all the rough movements are over, and nothing remains but to gently flex the thighs upon the pelvis.

The assistant who introduces the staff must not take his fingers off the instrument until it is finally removed from the bladder.

The patient being in the well-known lithotomy position, the surgeon seats himself beyond the end of the table, his face being on a level with the patient's perineum.

The presence of the stone should have been verified by the staff, or by a sound previously introduced.

The staff is held quite perpendicularly, and its concavity is drawn well up against the bony arch of the pubes. It is held rigidly and exactly in the median line. The assistant's thumb is placed upon the rough handle, while his fingers grasp the shaft. There must not be the least rotation of the instrument to one side or the other. In this position it is held throughout the operation and until it is withdrawn. The assistant at the same time holds up the penis and scrotum, and sees that the perineal raphë is exactly vertical.

The Operation.—*First* or *Superficial Incision.*— Steadying the integuments of the perineum with the fingers of the left hand, the surgeon makes the first incision. The knife is introduced at right angles to the surface of the peri-neum, and at a point just to the left of the median raphë, and just behind the central point of the perineum—*i.e.,* in the adult about one inch and a quarter in front of the anus. The knife is thrust in the direction of the staff, and its point may just hit the staff. This first movement is of the nature of a stab or a puncture.

The incision is completed as the knife is withdrawn. It is carried downwards and outwards into the left ischio-rectal fossa, and ends at a point between the tuber ischii

and the posterior part of the anus, and one-third nearer to the tuberosity than to the gut.

The incision will in the adult be about three inches in length. It becomes gradually shallower and shallower as it proceeds outwards and backwards from the median line.

Second or *Deep Incision.*—The left forefinger is now introduced into the wound and the staff felt for. This instrument will be perpendicular in position, and well drawn up against the pubic-arch.

The surgeon, keeping his eye upon the staff, to appreciate its position in the depths of the perineum, slips the knife along the back of the forefinger until it hits the groove in the staff.

There must be no doubt at this stage of the operation. The surgeon must be assured beyond question that he has found the groove, and that the knife occupies it.

The knife is now pushed cautiously along the groove until it reaches the end of the staff and enters the bladder. The blade should be inclined laterally as it is passed along, and be kept parallel with the line of the surface wound.

The incision made in the prostate will therefore be oblique, and directed downwards and outwards.

An escape of urine and a sense of abruptly diminished resistance will announce that the neck of the bladder has been divided.

Entering of the Bladder.—The left index finger is now introduced along the groove in the staff into the bladder. As soon as the surgeon is sure that he has his finger in the viscus, but not before, the staff is removed. The finger is then employed in dilating the neck of the bladder in all directions, and in ascertaining the size and situation of the stone.

The opening made by dilatation will have to accommodate itself to the size of the stone.

The dilatation must be made in all directions, and not only in the line of the wound.

Extraction of the Stone.—Without removing the left forefinger the surgeon introduces the lithotomy forceps along the upper or dorsal surface of the digit, and only

withdraws the finger when the forceps are well in the bladder.

The stone is seized and removed.

The line of traction in removing the stone should be in the line of the outlet of the pelvis. When the body is in the lithotomy position, therefore, the forceps must be drawn in a direction upwards and forwards.

The bladder is finally explored with the finger for other calculi or for fragments. If any *débris* remain, such as may be broken from a phosphatic calculus, the viscus is washed out with the syringe or irrigator.

Lateral Lithotomy in Children.—The operation in children is much modified by the anatomical conditions of the parts. The pelvis is relatively narrower than in the adult.

The usual incisions are made ; the staff is reached, and a relatively free incision is made into the neck of the bladder. The deep wound is examined with the finger. A pair of dressing forceps is then introduced along the staff into the bladder, and, by opening the blades, the wound in the vesical neck is cautiously enlarged.

The forceps are removed, and a probe-pointed director or common probe is then introduced into the bladder along the groove in the staff. The staff is withdrawn, but the probe or director is left in position, as a guide to the bladder, until the operation is completed. The finger is now introduced along the slender probe, and is slowly and cautiously wormed into the bladder. The stone may now be removed by appropriate forceps in the usual way, or its extraction may be effected by a scoop aided with the tip of the left forefinger, or the calculus may be worked out of the bladder by means of one forefinger introduced into that organ, and aided by the other forefinger inserted into the rectum.

II.—MEDIAN LITHOTOMY.

The Operation.—The method here described is that known as Allarton's.

The patient having been placed in lithotomy position,

the staff is introduced, and is held in the same manner as in lateral lithotomy. The surgeon inserts the left index finger into the rectum, and steadies the staff with the point of the finger which is pressed against it at the apex of the prostate.

The narrow bistoury is now thrust into the median raphë of the perineum half an inch in front of the anus. It is introduced horizontally, and with the cutting edge directly upwards. The groove in the staff is hit at the point where it is steadied by the finger in the rectum. The groove is entered at this point, and by continuing to thrust the knife deeper the apex of the prostate is slightly incised. The membranous urethra is cut through as the knife is being withdrawn, and the external wound is enlarged to the extent of about one inch by cutting upwards as the knife is being removed.

As the urethra is incised the handle of the knife will be pointing almost directly downwards; as the integuments are divided, the handle will be pointing upwards. Special care must be taken to avoid wounding the bulb.

A Little's director, or similar instrument, is now introduced along the groove of the staff into the bladder. It is held in the left hand. The staff is then withdrawn.

Guided by the director, which is retained in position until the operation is completed, the operator gradually worms his right forefinger into the bladder, dilating its orifice.

The forceps are now introduced, and the stone is withdrawn.

In ordinary cases no lithotomy tube need be employed.

CHAPTER II.

SUPRAPUBIC CYSTOTOMY.

Instruments required.—A scalpel; probe-pointed bistoury; scissors; sharp hook, blunt hooks; dissecting, artery, and pressure forceps; broad rectangular retractors; wound retractors; sound; lithotomy forceps and scoop; drainage tube for bladder; needles, sutures, ligatures, etc.

Distension of the Bladder.—A soft catheter is passed, the urine is drawn off, and through the catheter the bladder is washed out with a warm boracic solution (half an ounce to the pint). This is more conveniently done with an irrigator than with a syringe. The bladder is now filled with a weak warm solution of boracic acid. In children from two to five years of age, three to six ounces will probably suffice. In adults, eight to ten or twelve ounces may be introduced. The injection should be carried out by means of an irrigator held a few feet above the level of the table. The irrigator is detached, and a Wells's forceps or clip applied to the catheter prevents the fluid from escaping.

Opening of the Bladder. — An incision about three inches in length is made precisely in the median line immediately above the symphysis. The incision should be extended about half an inch actually over that process of bone. There is no linea alba below the umbilicus, and after dividing the skin and subcutaneous tissues, the surgeon may find muscular fibre lying across the line of the incision. If the interval between the muscles is not readily found, the knife should be carried directly through the muscle fibres themselves, the median line being strictly observed.

The wound must be a clean one, and any tearing of the parts with the fingers or forceps, or the handle of the scalpel, to seek for an intermuscular interval, is to be

deprecated. When substantial and powerful muscles are met with, it may sometimes be advisable to divide the fibres transversely, to a slight extent, close to their attachment to the bone.

Any bleeding points are secured with pressure forceps. The transversalis fascia is reached, and is divided in the same precise manner in the median line.

The area of connective tissue overlying the summit of the bladder is now exposed. This must be cleanly and precisely divided with the scalpel, and the bladder reached by dissection.

The peritoneum may possibly be made out and can be readily pushed upwards with the left forefinger. The dissection necessary to expose the bladder should be commenced close to the symphysis, and be continued cautiously upwards.

The bladder is recognised by its pinkish colour, by its rounded outline, and by the exposed layer of muscular fibres. The peritoneum, if in view, must be pushed upwards with the left forefinger, while the surgeon transfixes the bladder with a sharp hook. This hook should be introduced transversely across the median line, and should be inserted near the upper part of the exposed viscus.

The scalpel is now thrust vertically into the bladders exactly in the median line and just below the hook, and is made to incise the organ by cutting downwards towards the symphysis. It should be introduced with a sharp stab, lest the undivided mucous membrane be pushed inwards by its point.

The actual opening of the bladder is demonstrated by the escape of the contained fluid. The hold upon the tenaculum should not be relaxed. The cut-margin of the bladder on either side of the opening should now be seized neatly and symmetrically with pressure forceps. These enable the operator to maintain a hold upon the organ during the remainder of the operation, and they render the position of the opening perfectly distinct.

When the forceps are in place, but not before, the tenaculum may be removed.

The purpose for which the bladder has been opened is then carried out. If for the removal of a large calculus, this is extracted by scoop and finger, or by forceps. If for vesical tumour, this is removed with the aid of cutting forceps or curved scissors. If for prostatic enlargement, the mucous membrane over the projection is incised and enucleation carried out by the fingers, aided perhaps by an elevator or forceps. The prostatic urèthra should be as far as possible respected.

Suturing of the Bladder.—This is an ideal method of concluding the operation whenever it can be carried out. The bladder wound should be closed by suture in children, and in healthy adults provided that the viscus itself is normal.

It is not wise to attempt it in aged subjects, in those who have cystitis, or in cases where the operation has been protracted, and the margins of the bladder wound are much bruised, as in the extraction of a large calculus. ·

The application of the sutures is comparatively easy in children and in thin adults. It is difficult in the corpulent.

The opening into the bladder is fixed, and is held up by two blunt hooks, one inserted at each extremity of the wound. By means of these hooks the margins of the incision are kept steady and parallel with one another. Fine catgut or kangaroo tendon should be employed. The sutures should be interrupted, and should be in two rows or layers. The deeper series should include the mucous membrane. The surface layer should include the other coats. All sutures should be introduced by means of a curved needle in a holder, and be very closely applied.

A small gauze drain is introduced into the lower part of the parietal wound, which is then closed.

In many cases, however, such as for removal of an enlarged prostate, no attempt at suturing should be made, the urine being allowed to drain freely through the wound until the latter spontaneously closes. A dry dressing is applied:

CHAPTER III.

Operative Treatment of Stricture of the Urethra.

INTERNAL URETHROTOMY.

A GREAT variety of urethrotomes have been devised, but Teevan's modification· of Maisonneuve's instrument is perhaps the best. In this the knife-blade is made to divide the stricture from in front, Teevan's improvement consisting in a guide bougie of fine calibre, which is screwed on to the end of the urethrotome, and is passed on into the bladder. Before use, the instrument should be carefully examined, so as to avoid the risk of the bougie breaking off, etc. The guide bougie must be flexible, and yet with sufficient rigidity to enable the stricture to be passed.

The urethral canal is straightened by the surgeon making traction with the left hand whilst the bougie is introduced. If the stricture be very tight, the instrument is apt to double back, in which case another bougie should be tried. As soon as there is no doubt it has entered the bladder, the urethrotome is screwed on to the bougie, and both are well oiled, the instrument being then passed onwards until the knob of the urethrotome presses against the stricture. The urethrotome is depressed so that its handle lies between the patient's thighs. The knife-blade is then made to protrude one or two millimetres from its guard, and the stricture divided on either side of the median line. After each cut of the knife, the latter is withdrawn within its guard. When it is thought that the stricture is sufficiently cut, the urethrotome and guide are withdrawn, and a large-sized Lister's metal sound is passed.

It may be necessary to reintroduce the urethrotome and repeat the notching, and the surgeon should not be content until a full-sized Lister's sound or a bougie of the

size of No. 25 (French) can readily be passed. The hæmorrhage is, as a rule, very slight. Finally, a full-sized silver catheter is passed and the bladder emptied. During the whole operation, the patient must be warmly wrapped up in blankets, and the same precaution observed afterwards. It is best not to leave a catheter in the urethra, and to allow the parts to rest for two or three days before again passing a Lister's sound of large calibre or a flexible bougie. Subsequently the regular introduction of the latter must be insisted on to prevent recurrence of the stricture.

EXTERNAL URETHROTOMY.

1. **Syme's Operation.**—*Instruments Required.*—Syme's staff. (This instrument has a narrow terminal part, which is passed through the stricture. Where this part joins the rest of the staff there is a "shoulder," which rests against the distal surface of the stricture. The narrow segment is grooved, and the groove is continued on to the shoulder.) Manacles or Clover's crutch; scalpel; probe; director; Teale's probe gorget; perineal tube; catheter.

The Operation.—The patient is placed in lithotomy position, and the staff is introduced with the care already advised in that operation. An incision is made precisely in the median line of the perineum, and the knife is so directed that its point shall hit the shoulder of the instrument. The surgeon must convince himself that this portion of the staff is laid bare. He then engages the point of the knife in the groove of the staff, and, keeping most carefully to the groove, thrusts the knife towards the neck of the bladder until he has divided the whole of the stricture. A director or probe, or Teale's probe gorget, is now introduced along the convexity of the staff into the bladder, and the staff is removed. A gum-elastic catheter may then be passed into the bladder through the penis, and be guided into position by the director or probe gorget, aided by the finger inserted in the wound.

Should the irritability of the bladder prevent the

retention of a catheter, a tube should be passed into the bladder from the perineum, and should be retained in position by tapes.

Syme's curved perineal catheter may be employed for this purpose, or a portion of a gum-elastic catheter be made use of. Whitehead's perineal tube, with sliding adjustable shield, is a useful instrument.

As soon as possible, however, a catheter should be passed by the meatus, and the perineal wound allowed to close.

2. **Wheelhouse's Operation.**—*Instruments Required.*—Manacles or Clover's crutch; Wheelhouse's hooked staff; two pairs of fine-nibbed forceps; scalpels; catheters; probe; probe-pointed director; Teale's probe gorget; curved needle; needle-holder; artery and pressure forceps; sponges in holders.

The Operation.—The patient is placed in lithotomy position. "The staff is to be introduced with the groove looking towards the surface, and brought gently into contact with the stricture. It should not be pressed much against the stricture, for fear of tearing the tissues of the urethra and causing it to leave the canal, which would mar the whole after-proceedings, which depend upon the urethra being opened a quarter of an inch in front of the stricture. Whilst an assistant holds the staff in this position an incision is made into the perineum, extending from opposite the point of reflection of the superficial perineal fascia to the outer edge of the sphincter ani. The tissues of the perineum are to be steadily divided until the urethra is reached. This is now to be opened in the groove of the staff, not upon its point, so as certainly to secure a quarter of an inch of healthy tube immediately in front of the stricture. As soon as the urethra is opened, and the groove in the staff fully exposed, the edges of the healthy urethra are to be seized on each side with straight-bladed nibbed forceps, and held apart. The staff is then gently withdrawn until the button-point appears in the wound." It is then turned round, so that the point hooks on to the front edge of the urethral wound, which is thus

" stretched open at three points, and the operator looks into it immediately in front of the stricture. While thus held open, a probe-pointed director is inserted into the urethra, and the operator, if he cannot see the opening of the stricture—which is often possible—generally succeeds in very quickly · finding it, and passes the point onwards through the stricture towards the bladder. The stricture is sometimes hidden amongst a crop of granulations or warty growths, in the midst of which the probe-point easily finds the true passage. The director having been passed into the bladder (its entrance into which is clearly demonstrated by the freedom of its movements), its groove is turned downwards, the whole length of the stricture is carefully and deliberately divided on · its under surface, and the passage is thus cleared. The director is still held in the same position, and a straight probe-pointed bistoury is run along the groove, to ensure complete division of all bands or other obstructions. These being thoroughly cleared, the old difficulty of directing the point of a catheter through the divided stricture and onwards into the bladder is to be overcome. To effect this, the point of a Teale's probe gorget is introduced into the groove in the director, and, guided by it, is passed onwards into the bladder, dilating the divided stricture and forming a metallic floor, along which the point of the catheter cannot fail to·pass securely into the bladder. The entry of the gorget into the latter viscus is signalised by an immediate gush of urine along it. A silver catheter (No. 10 or 11) is now passed from the meatus down into the wound, is made to pass once or twice through the divided urethra, where it can be seen in the wound, to render certain the fact that no obstructing bands have been left undivided, and is then, guided by the probe-dilator, passed easily and certainly along the posterior part of the urethra into the bladder. The gorget is now withdrawn, the catheter fastened in the urethra, and allowed to remain for three or four days, an elastic tube conveying the urine away. After three or four days the catheter is removed, and is then passed daily, or every second or third day, according to

circumstances, until the wound in the perineum is healed;
and after the parts have become consolidated, it requires,
of course, to be passed still from time to time, to prevent
re-contraction."— *Wheelhouse.*

The operation requires good light and infinite patience.
There is often some difficulty in detecting the orifice of the
stricture, and matters may be complicated by a false
passage.

Part XI.

OPERATIONS ON THE SCROTUM AND PENIS.

CHAPTER I.

OPERATIVE TREATMENT OF VARICOCELE.

The Operation.—The operator stands on the left side, one assistant raises and steadies the cord by holding the testis with his fingers from below, whilst another sponges. An incision is made, one and a half inches long parallel to and directly over the cord, immediately below the external ring. The cut divides skin, connective and fatty tissue, the intercolumnar fascia, and the cremasteric layer. The latter is easily recognised by its longitudinal muscle bands. The edges of this fascia are then held aside by Wells's forceps, and the anterior bundle of veins comes into view covered by the thin infundibuliform fascia. The latter is then carefully divided and peeled off with forceps, so that an aneurysm needle can be introduced under the veins, but in front of the vas deferens. The veins must be perfectly bared, and cleanly exposed. It must be ascertained for certain that the vas and the vessels which lie behind it are not included. A catgut ligature of medium thickness is then drawn under the anterior bundle, which is cleared of surrounding tissues for a distance of about two inches. If it is desired that the lower part of the veins should be ligatured rather than the upper, they can be easily reached by making traction on the cord. A second ligature is introduced, and the veins are then ligatured in two places, about one inch and a half apart. The lower ligature should be tied first. The vessels so isolated are divided with scissors close to the ligatures and removed.

The amount excised will be represented by about one inch, the scissors being applied about a quarter of an inch from the ligature.

There is no need to clamp the veins above the site of the proposed excision in order to render them distinct.

Almost invariably the spermatic artery will be included in the ligatures, as it lies surrounded by the veins of the anterior bundle.

After the intervening portion has been excised, the two cut ends are secured together by tying the two ligatures above to those below. This union may be reinforced by a few fine catgut stitches introduced with a curved needle through the opposing empty vessel-ends.

If two pairs of dissecting forceps are gently used in clearing the varicocele from the surrounding tissues, there is little risk of damaging the vessels. The action of the forceps must be supplemented by the scalpel. There must be no tearing of the fascia asunder with the fingers.

There will probably be no bleeding points to secure.

A blunt hook having been inserted at each extremity of the wound, in order to bring the edges of the incision parallel, the sutures are introduced. Fine red silkworm gut should be employed.

Excision of Part of the Scrotum.—This proceeding should be reserved for the exceptional cases of extreme laxity of the skin and muscles supporting the testicle. The pendulous scrotum is drawn through a pair of narrow-bladed curved forceps, such as are used in circumcision, until the testis is seen to be well braced up. The forceps (their convexity being downwards) are then held firmly whilst the redundant tissues are excised with a sharp-pointed bistoury. On relaxing the grip of the forceps there will be free oozing from the scrotal veins and arterial twigs. This should be thoroughly stopped by pressure forceps, and if necessary by ligature, before the wound is sewn up. All sutures in the scrotum must be introduced close to the edges of the wound; otherwise the dartos tucks in the skin and prevents rapid healing.

CHAPTER II.

OPERATIVE TREATMENT OF HYDROCELE. ·

Excision of the Parietal Part of the Sac.— This operation is the most certain to lead to a cure of the hydrocele, and conforms to the modern principles of surgery. This method is especially adapted for hydroceles of the tunica vaginalis or of the epididymis in adults. Hydroceles of the cord are also best treated by excision, though in this case the entire sac is removed, whereas in hydrocele of the tunica vaginalis only the parietal portion is removed.

An incision about three inches long is made over the long axis of the hydrocele at its upper part, and is carried down through the cremasteric layer. With forceps the tissues immediately covering the sac are peeled off on either side, whilst the hydrocele is pushed out of the wound as far as practicable. It is convenient not to open the sac until it has been well laid bare on either side. A puncture is then made and the fluid evacuated ; the sac is laid freely open with scissors and then cut away. Care must be taken in doing this to keep just outside the epididymis externally and not to injure the vessels of the cord or the vas deferens internally. It should be remembered that in old hydroceles the body of the epididymis is often displaced from the testis by a pouch. Fig. 116 shows the relation of the upper part of the sac to the cord, etc., and indicates how much may safely be cut away. It is easy to destroy the epithelial covering on the testis by scraping it lightly with a Volkmann's scoop, but it may be doubted whether this is necessary. In any case rough handling of the testis should be avoided. Any bleeding points are secured with pressure forceps, but ligatures are rarely required.

. If oozing persists, a small drainage-tube should be inserted at the lower angle of the wound, to be removed twenty-four hours later. The sutures should be of fine silkworm-gut, and should be placed close to the edges of the wound.
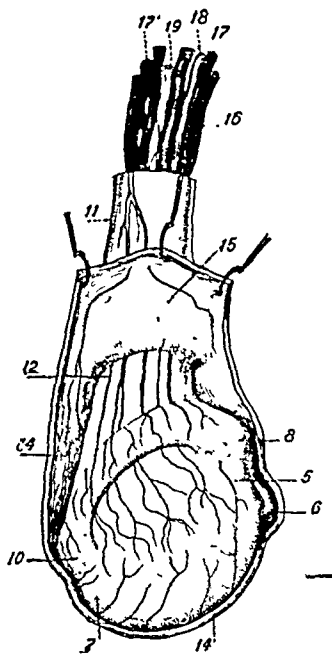
Fig. 116.—NORMAL RELATION OF THE TUNICA VAGINALIS TO THE TESTIS AND CORD, SHOWING THE AMOUNT OF THE SEROUS COAT TO BE EXCISED IN THE RADICAL OPERATION FOR HYDROCELE.

The operator should cut just outside the line of reflection shown in this figure, with particular care not to damage the epididymis or vessels of the cord. 5, Junction of globus major with testis; 6, Hydatid of Morgagni; 7, Junction of globus minor with testis; 8, 14, 15, Tunica vaginalis, parietal layer; 10, Globus minor; 11, 12, Spermatic cord: 16, 17, 18, Anterior bundle of veins and spermatic artery; 19, Vas deferens; 17', Posterior bundles of veins. (*After Testut.*)

CHAPTER III.

CASTRATION.

Instruments required.—A median-sized scalpel; scissors; razor; dissecting forceps; Wells's artery forceps (several pairs); a clamp; two large blunt hooks; aneurysm needle; catgut ligatures; curved needles and needle-holder; suture material; drainage-tube. The clamp is the only special instrument required; its blades should be protected by rubber to lessen the crushing of the vessels of the cord.

Position.—The patient lies upon the back, with the thighs extended and a little apart. The surgeon stands on the same side of the patient as the organ to be removed. The one assistant required stands on the other side of the table, opposite the surgeon. His most important duty is to keep hold of the cord after it has been divided.

The Operation.—The pubes must be shaved, and the hair removed from the scrotum as far as possible. The scrotum, groin, and perineum should have been previously washed repeatedly, and antiseptic measures adopted (with caution as to the scrotal skin, which is easily made sore by too strong lotions).

The testicle may rest upon a large sponge placed between the thighs. The skin of the scrotum is steadied by the left hand in this manner: the thumb and fingers are separated; the thumb lies on the right side of the swelling, the fingers on the left, the wrist is towards the abdomen, and the finger-tips towards the bottom of the scrotum. The incision is made between the thumb and the fingers, and by the separation of these the skin is well steadied and stretched.

A vertical incision is carried from a point about one inch below the external abdominal ring to the bottom of the scrotum.

When the skin is involved by the growth, or when it

has become adherent to the testis or is the seat of sinuses, two elliptical incisions that clear the affected skin and meet above and below should be made. The position of these elliptical cuts must obviously depend upon the position of the implicated skin, and they may have to be made upon the lateral or even the posterior aspects of the scrotum. In dividing the tissues between the skin and the tunica vaginalis, the soft parts should be gently moved to and fro by the left hand, which still keeps its position on the scrotum. The mobility of the superficial layers is striking, but the tunica as it is approached is recognised by its perfect immobility.

When the skin is involved, this means of noting the progressive depths of the incision is lost.

The testis may be removed without opening the tunica vaginalis. In such case the tunica, as a simple bag, may be separated from the scrotal tissues with the fingers. While this is being done, the assistant should hold the scrotum and the testicle of the opposite side. In a large number of cases, however, it is desirable that the tunica should be opened : first, for diagnostic reasons ; second, to lessen the bulk of the swelling when the sac is distended with much fluid ; third, when the tunica is adherent, owing to the progress of the growth or the disease.

The testis is now shelled out of the scrotal tissues with the fingers. It is practically torn out, and at this step all cutting should be avoided, except when a point resists the fingers.

Even after the serous sac has been opened, the tunica vaginalis can very usually be shelled out together with the testis, to which it clings.

If the testis alone be disturbed, the connections between the visceral and parietal layers of the tunica must be cut with scissors.

In exposing the tumour, care should be taken not to cut into it. The operation is complicated by opening an abscess cavity or a cyst, or by cutting into a mass of soft growth.

The cord is now well isolated with the fingers, and drawn down. It is then secured by a clamp. The best

clamp for the purpose is a Spencer Wells's large pressure forceps. The assistant holds the clamp, and the surgeon, grasping the testicle, divides the cord with the knife about three-quarters of an inch below the clamp. The vessels of the cord can now be separately secured. Three arteries must be ligatured—the artery to the vas deferens, the cremasteric, and the spermatic. The deferential artery is found close to the vas. With it are a few veins (the posterior set, Fig. 116). The cremasteric artery lies towards the outer part of the cord and nearer its surface. The spermatic artery is in front of the vas, and is surrounded by the veins of the pampiniform plexus. It is impossible to distinguish the arteries from the veins. The mouths of the latter vessels gape when grasped by the clamp ; they are thereby rendered obvious, and are readily secured. Both veins and arteries are picked up with artery forceps, and secured with catgut. The two sets of veins should be tied separately. Three or four ligatures may be required, but very seldom more.

These ligatures should certainly be of catgut and not of silk, for fear of a troublesome sinus resulting. They should be knotted very securely before the clamp is relaxed, and should be left long until it is seen that all the vessels have been well tied.

Any bleeding points in the scrotal incision must be secured. The following vessels are divided :—superior and inferior external pubic, superficial perineal, and the artery to the scrotal septum. As a rule, none of these needs a ligature.

In applying the sutures, either straight or curved needles may be used, threaded with fine silkworm gut or catgut. In order to obtain an even line of union the edges of the incision should be stretched between two blunt hooks, inserted at the extremities of the wound and held by the assistant. This will prevent the in-turning of the edges of the incision, due to the contraction of the dartos, and will allow of accurate adjustment of the parts. It is well to introduce all the sutures before tying the first one. A drainage-tube one inch and a half long may be secured by means of the last suture.

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CHAPTER IV.

Amputation of the Penis.

This operation is required principally for cases of epithelioma.

Instruments required.—For the operation to be described, the following instruments are needed : An elastic band tourniquet ; a gum-elastic catheter ; a scalpel ; a narrow straight bistoury ; straight and curved scissors ; a tenaculum ; dissecting, toothed, and artery forceps ; small curved needles and needle holder for the urethra ; straight needles ; ligatures.

Amputation of the Free Portion of the Penis by Dorsal Flap.—The hair about the root of the penis having been shaved off, the parts are rendered as aseptic as possible in the usual way. The patient lies in the usual position, with the thighs slightly abducted; the surgeon stands on the right side of the patient. Previous to the operation the rectum and bladder should have been emptied. An elastic tourniquet—a No. 9 soft rubber catheter answers admirably—is tied around the root of the penis. The tourriquet may be prevented from slipping forward by applying it behind a sterilised hare-lip pin used to transfix the penis.

The end of the penis is then held by an assistant with forceps, and a rounded dorsal flap of skin and fascia shaped out and dissected up. This flap must be of sufficient dimensions to cover the whole section of the penis, and it should be made well behind the edge of the epithelioma. The flap being held back, the penis is transfixed with a narrow-bladed bistoury between the corpus spongiosum and the corpora cavernosa. In order to guard against the risk of injuring the roof of the urethra with the knife it is well to have introduced a catheter before transfixion. The blade

of the knife is then turned upwards, and the two corpora cavernosa are divided at the level of the base of the skin flap.

The urethra is now dissected out for nearly an inch in front of the point where the knife was introduced, and
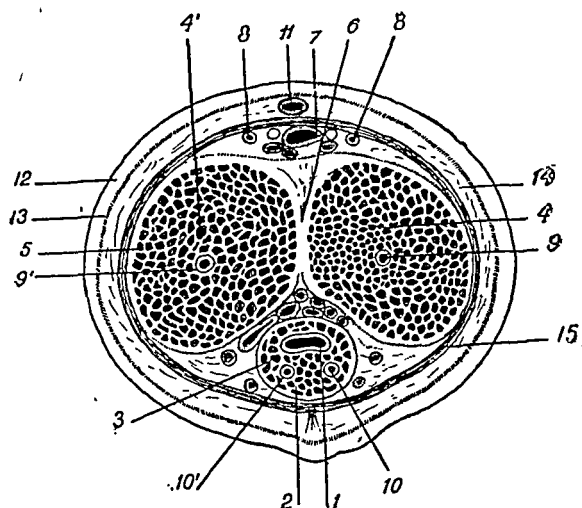
Fig. 117.—SECTION OF PENIS SHOWING THE VESSELS REQUIRING LIGATURE IN AMPUTATION THROUGH THE ORGAN. (*From Testut's Anatomy.*)

1, Urethra; 2 and 3, Corpus spongiosum; 4 and 5, Corpus cavernosum; 6, Median septum; 7, Dorsal vein; 8 and 8', Dorsal arteries; 9 and 9', Arteries of corpus cavernosum; 10 and 10', Arteries of corpus spongiosum; 11, Additional dorsal vein beneath skin; 12, Skin of penis; 13, Dartos layer; 14, Cellular tissue; 15, Fascial sheath.

severed at this level. The skin on the under surface of the penis is divided transversely from one side of the dorsal incision to the other. There has been hitherto no hæmorrhage, and before removing the tourniquet all the chief arteries and veins are carefully secured with catgut ligatures (Fig. 117). The tourniquet is now removed, and any bleeding points are dealt with.

A small incision is made through the dorsal flap, and

the stump of the urethra drawn through this opening; the end of the urethra is notched on both sides so that it can be everted and sutured all round to the margin of the opening in the flap. The edges of the latter and of the skin below are then sutured. Either fine silk or catgut may be used—the latter has the advantage of not requiring subsequent removal. It is difficult to keep any dressing applied, and none is really required. Some boraric and iodoform powder may be dusted on. It is well to leave the ends of two of the sutures which secure the new meatus long, as they facilitate the passage of a catheter during the next day or two. However, as a rule, the patient will be able to pass his urine without an instrument. It will be seen that by this method no raw surface is left, requiring slow cicatrisation with its attendant risk of stricture. Healing is therefore rapid, and the patient need not be kept in bed for more than a week or so. One point in the operation is of special importance : to take plenty of time in securing all bleeding vessels before the flap is sewn down. The use of the tourniquet is essential. If any lymphatic glands in either groin are enlarged, they should be excised at the same time as the amputation of the penis. This is done through an oblique incision on one or both sides, the cut running parallel to Poupart's ligament.

Part XII.

OPERATIONS ON THE RECTUM.

CHAPTER I.

OPERATIVE TREATMENT OF HÆMORRHOIDS.

THE bowels must be well opened by an aperient—preferably castor oil—administered thirty-six hours before the operation is performed. Just before the surgeon's arrival the rectum should be thoroughly cleared out by a warm water enema, and the nurse should be careful to see that all the fluid injected is returned. A hot bath should be taken on the evening before the operation.

Instruments required. — *Ligature Operation.* — Clover's crutch; pile-holding forceps (there are many forms of these forceps—some resemble the volsella, others are constructed on the principle of the pressure forceps, and another series follows the mechanism of artery torsion forceps, and is provided with a sliding catch—it is desirable that the instrument should be self-holding); scissors—sharp and blunt-pointed, straight, and curved on the flat (special forms of hæmorrhoid scissors, such as the well-known scissors or shears introduced by Salmon, are not specially convenient); pressure and artery forceps; silk.

Excision Operation.—The same instruments, with the addition of dissecting forceps, volsella, needles and needle-holders, scalpel, catgut ligatures, sponges in holders. A rectal speculum may be of use.

1. **Operation by Ligature.** — The patient is anæsthetised, Clover's crutch is applied, and the patient is placed in the lithotomy position, the buttocks being brought

close to the lower end of the table. The surgeon sits facing the perineum.

The first step consists in dilating the sphincters. Both index fingers are introduced, and the anus is slowly and gradually stretched. The process will require at least two minutes to accomplish, and when complete the anus will be patulous, and the sphincter will have lost its tendency to contract. If a hasty dilatation be effected, the sphincter may relax suddenly, and a laceration of the parts be brought about. The surgeon should maintain a watchful control over the dilating fingers.

The parts are now in a convenient condition for operation. The piles, which may previously have been entirely withdrawn from view, are now readily exposed, and the whole of the lower part of the rectum can be inspected and explored. The surgeon, after a careful examination of the district, should decide on the number of piles which may require removal.

It is desirable to commence with the hæmorrhoids on the lower or posterior wall of the rectum, since, when the piles on the opposite wall are being dealt with, these are obscured by the blood. Small piles, which are evident enough before the actual operation is commenced, may be lost sight of after some of the main ligatures have been applied. As a preliminary step, it is well to seize each of these smaller excrescences with pressure forceps, which are left in position, as a guide to the site of the pile, until the surgeon finds it convenient to deal with them. These forceps hang loose, and are not in the way.

Each pile is seized with the pile-holding forceps, held in the left hand, and is gently drawn away from the anus and towards the middle line. Its base is thus rendered tense, and the line of junction of the skin with the mucous membrane is brought well into view.

By a series of snips with the scissors the surgeon severs all the *lower* attachments of the pile, cutting along the line of junction of the skin and mucous membrane.

By a few light snips, aided with a little pressure from the blunt points of the scissors, the pile is dissected up from

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the submucous tissue until it is attached only by the healthy mucous membrane above it, and by the vessels that are descending to enter it. As the vessels come from above and run just beneath the mucous membrane, and enter the upper part of the hæmorrhoid, this detachment is readily and safely accomplished, and the bleeding is very trivial.

The detachment should be sufficiently extensive to form a deep groove.

The forceps are now handed to an attendant, who maintains a traction upon the pile, while the surgeon places a silk ligature round its pedicle, which he at once proceeds to tie as tightly as possible.

The ligature should not be too thick, and it should not be applied with such violence as to cut the pedicle of the pile entirely through. Before tightening the knot, the ligature should be so manipulated as to include the highest part of the mucous membrane left attached to the pile.

There are two points to be specially attended to in applying the ligatures. The groove in which each lies must be made within the margin of the external sphincter, so that the ligature includes no part of the muscle. Secondly, there must be no risk of the ligature slipping after the stump has been returned, for most troublesome hæmorrhage may then result. The tighter it is tied the better, and a third knot should be made for security. The scissors should not be applied too closely to the ligatures.

The number of ligatures to be applied will of course vary. More than five will seldom be required.

The operation is completed by cutting the ligatures off, and by snipping away about two-thirds of the strangulated hæmorrhoidal tissues which project beyond the knot. The parts are lightly dried and returned within the sphincter.

A soft pad of moistened gauze, over which is a square pad of absorbent wool, is then secured in place by a firm T-bandage. It is customary to insert a suppository containing a quarter to half a grain of morphia within the rectum before applying the dressing.

2. **Excision of the Hæmorrhoidal Area** (*White-head's Operation*).—The patient is secured in the litho-

tomy position by means of Clover's crutch. The perineum is shaved if necessary. The sphincters are very thoroughly dilated, and the piles are made to protrude completely. As blood soon obscures the view, it is best to commence the operation at the lowest point of the anal margin, then to proceed to the sides, and finally to the upper margin. By means of a short, sharp scalpel the mucous membrane is divided at its
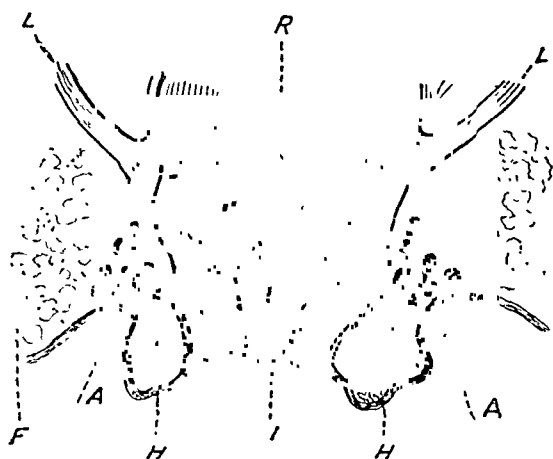
Fig. 118.—TRANSVERSE VERTICAL SECTION THROUGH RECTUM, THE SITE OF MARGINAL HÆMORRHOIDS (HH).

LL, Levator ani ; AA, Sphincter ani externus ; F, Fat in ischio-rectal fossa. The dotted line I shows the level at which the mucous membrane should be divided in Whitehead's operation ; the point at which the dotted line running up from AA crosses the perianal skin indicates the line at which the latter should be divided.

exact point of junction with the skin around the entire circumference of the anus. All the inequalities of the surface are followed, and in places where the skin is distinctly redundant a variable amount of integument is included in the part to be removed—*i.e.*, in such places the knife travels a little away from the mucous membrane. Two assistants are present, who stand one on either side of the operator. As soon as the above incision is completed, pressure forceps are

attached to the margins of the cut skin at four equidistant parts, which may be referred to as north, south, east, and west of the anal orifice. Pressure forceps are also attached to corresponding points on the margin of the divided mucous membrane. By drawing in opposite directions any two companion forceps, the separation of the mucous membrane at that point is much assisted.

The circular incision is gradually deepened, most conveniently with blunt-pointed straight scissors aided by forceps. The separation of skin and mucous membrane is carried out until the external sphincter is recognised. Its most external fibres are indistinct, but there is very little difficulty in soon demonstrating its form as a circular band of muscle, which is carefully preserved. As soon as the external sphincter is cleared, the separation of the mucous membrane becomes easy.

The surgeon must remember that the operation consists in the excision of an unbroken circle of mucous membrane and submucous tissue containing veins, and of nothing else. The separation of this ring or tube of mucous membrane is readily accomplished by the blunt point of the scissors, aided by the finger, and at every step assisted by traction upon the forceps, which are fixed to the cut edge of the mucous membrane. To aid such traction, additional forceps (in excess of the four already in use) may be attached to the mucous membrane where needed. The tube of mucous membrane must be well and evenly isolated all round, and the separation must be continued up to a point at least half an inch above the intended line of section. The internal sphincter is in no way disturbed. Up to this point the bleeding is trifling, and any vessels which give trouble are seized with pressure forceps and dealt with by torsion.

The surgeon now proceeds to cut through the isolated tube of mucous membrane, which includes all the piles and, indeed, all the pile-bearing district. He introduces the forefinger of the left hand into the mucous tube, and divides it in a circular line, which is at right angles to the long axis of the rectum. He makes the division bit by bit, while an assistant draws upon the forceps which have been fixed to

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the anal edge of the mucous membrane. As each vessel is divided, it is secured by pressure forceps. A little experience will teach the operator where the vessels lie, so that their division is not made unexpectedly. In due course the involved mucous membrane (with the original forceps still attached) is entirely removed as an unbroken ring or tube. There then remains the divided line of skin with the original forceps still attached, and the divided line of mucous membrane, to which some six to ten forceps, securing vessels, will be attached.

The sutures are now ready to be applied. The best suture material is fine chromicised catgut used absolutely dry. The suture is of good length, and is carried in a curved needle held in a suitable needle-holder. The surgeon passes the needle through the edge of the divided skin, and then, taking up in his left hand one of the forceps affixed to the mucous membrane (and also grasping a cut vessel), he passes the needle through the mucous membrane in such a way as to take up the vessel in question. He then removes the forceps and ties the ligature in a firm surgeon's knot. Thus the cut edges of the skin and mucous membrane are brought together, and the divided vessel in the latter membrane is secured by being as it were underpinned by the single suture. In this way the wound is closed all round. From ten to twenty sutures will be required. No vessel needs to be ligatured, nor even to be twisted. The suture controls each one quite perfectly. Additional sutures are applied when required. The suture involves only the skin, the mucous membrane, and the vessel in the submucous tissue. The sphincter is excluded entirely from it.

CHAPTER II.

Operation for Anal Fistula.

Operation.—The patient is prepared in the same manner as is described in the previous chapter.

He is placed in lithotomy position, and is secured there by a Clover's crutch. It is assumed that an external opening exists. A Brodie's probe-pointed fistula director is introduced into the fistula, and is passed into the bowel through the internal opening. Not the very least force must be employed. The internal opening might have been already detected, and the passing of the probe may be carried out while a speculum keeps the inner opening in view. If the director does not easily pass, a flexible or especially bent probe may be introduced. If the probe is found to present under the thinned mucous membrane in a case in which no internal opening exists, the point of the director should be thrust through the mucous membrane at the thinnest spot. In every case, when possible, the probe should be passed while the left forefinger occupies the rectum and acts as a guide.

In a simple case in which the inner orifice is low down, the point of the director may be engaged upon the tip of the left forefinger (lying in the rectum), and may be cautiously brought outside the anus. Nothing then remains but to slit up the fistula with a sharp-pointed curved bistoury.

When the inner opening is high up, persistent attempts to bring the point of the director out of the anus may lead to undue laceration of the part.

In such a case, the sphincter having been very fully dilated, the interior of the bowel must be well exposed by means of a suitable speculum and well illuminated by

means of a small electric lamp. The division is then made while the parts are in full view of the operator.

After the division of the fistula comes the most delicate part of the operation—the search for secondary fistulæ, for burrowing tracts, and for diverticula from the primary sinus. For this examination again are needed a well-stretched sphincter, a speculum, rapid sponging, a good light, and suitable probes.

The finger should search for any tracts of indurated tissue, and the surgeon should note if the escape of a bead of pus follows pressure in any direction.

Any secondary sinuses must be treated as their condition indicates. Those which burrow beneath the mucous membrane should be slit up for their entire length. No object is gained by sparing the mucous membrane, and hesitating and incomplete incisions will always be regretted. Secondary sinuses, which pass away from the rectum, must be liberally slit up. When this involves too great a division of the soft parts, they may be freely opened into the original wound, may be dilated with dressing forceps and the finger, and well scraped with a sharp spoon or seared with the actual cautery, and then well stuffed with gauze.

All the pulpy granulation tissue which is met with about fistulæ should in every case be scraped away. The surgeon should endeavour to leave as clean and fresh a wound as possible.

In the division of the fistula the anal margin is of necessity in every case divided, and in order that the section of the muscle fibres should be as direct as possible, the knife should always cut its way into the bowel at right angles to the anal margin.

If any piles exist, they should be removed at the time of the operation, and all ill-nourished flaps and tags of inflamed and undermined skin should be cut away.

Part XIII.

OPERATIONS ON THE HEAD AND SPINE.

CHAPTER I.

TREPHINING.

I.—TREPHINING IN FRACTURE OF THE SKULL.

Instruments required.—Trephines of various sizes ; a quill ; a pair of Hey's saws ; a small pair of bone-cutting forceps ; slender chisel and mallet ; a gouge ; a pair of gouge forceps, such as Hopkins's rongeur, or Hofmann's modified form ; an elevator ; periosteal rugine ; necrosis forceps ; scalpels ; dissecting and Wells's forceps ; scissors ; dressing forceps ; fine-toothed forceps, and fine scissors for the dura mater ; small tenaculum or slender curved needle in a handle for bleeding vessels ; probe ; needles and sutures.

Preparation of the Patient.—The head is shaved, then washed with soap and water, and scrubbed with a nail-brush. It is next washed with ether, and finally with a 1 in 20 solution of carbolic acid in alcohol, or the 1 in 500 alcoholic solution of biniodide of mercury.

The head is conveniently supported upon a sand-bag covered with macintosh sheeting and sterilised towels.

The Operation.—When any wound already exists, the fracture is exposed by enlarging it as required. When the scalp is sound, a semilunar flap may be raised, the free end of which points vertically downwards. It should form a shallow curve, and be so planned as to avoid the main scalp arteries.

Or a V-shaped incision may be employed, with the apex of the V pointing downwards. In any case, the flap should be of ample size, and should be so placed as to allow of the free draining away of blood.

The incision should be carried at once down to the bone, and the pericranium having been detached with a curved rugine, the flap as it is turned up will be composed of all the soft parts covering the skull.

A long silk suture should be inserted into the free end or apex of the flap, and by means of this thread the flap is drawn up and held out of the way.

The bleeding from the scalp tissues is usually free. The more conspicuous bleeding points are neatly secured by pressure forceps; sponge pressure will check mere oozing.

The fracture is now exposed and examined. It may be found to be at once possible to introduce an elevator beneath the depressed bone, and to elevate it. Fragments at the same time may often be readily removed by means of dressing forceps or necrosis forceps.

In other cases a rim of projecting bone—belonging to the sound part of the skull—may be removed with a narrow chisel and mallet, or with Hey's saw, or with the gouge or gouge-forceps, and a little space is at once provided between the bones which will allow of an elevator being introduced. In this part of the operation it must be confessed that Hey's saw is of little use. Indeed, Hey's saw is not a serviceable instrument, and it is rarely employed.

The elevator must be introduced with care. It is apt to slip, and such an accident is least possible with Horsley's instrument. In raising the depressed bone, it is needless to say that the elevator must be supported upon the sound part of the skull.

Sometimes when the bone is much comminuted one fragment will be found to be so tilted outwards that it can be seized and removed, and through the gap thus left the elevator or the blade of the dressing forceps or necrosis forceps can be introduced.

In a comparatively few cases the trephine will be

needed. The centre-pin of the instrument is introduced ; the crown is then applied to the sound bone near to the fracture. As a rule, it is so applied that two-thirds or three-fourths of the circle will be upon the sound skull, and the remaining third or fourth over the fractured area. The trephine should not be placed so far over the injured area as to produce trouble by jarring any fragment which may be lying in contact with the dura mater.

The point is bored into the bone, and then the trephine is made to cut into the skull by light sharp movements from left to right, and from right to left.

At first the instrument may be steadied by the left fore-finger, which rests upon the skull. As soon as a groove has been cut all round, the pin may be withdrawn, and the instrument will be found to maintain a steady hold of the part. The pressure must be evenly maintained throughout, and will be found to be chiefly exercised when the hand is turned from left to right (the supination movement). At first the bone-dust is dry, but as soon as the dense outer table is cut through it becomes soft and bloody. As the trephine enters the diploë the softer character of the resisting medium is at once recognised.

The wound in the bone must be kept constantly clear of dust by frequent irrigation and the use of the quill. The depth of the groove in the skull must be estimated from time to time with the quill. Inasmuch as the skull is spheroidal, it is exceedingly difficult to make the groove of equal depth all round. The shallower parts must be especially cut down to the level of the deeper parts, by bearing pressure upon the bone at the points where the division has been less complete. As the inner table is penetrated, increased caution must be exercised, and still more care is needed when once the groove has been extended right through the skull. It must be remembered that the bone will probably be of unequal thickness even over the small area covered by the trephine.

When the groove is of sufficient depth, the disc of bone may be removed by gently rocking the trephine to and fro while it is still in position, or by cautiously introducing an

elevator at a spot where the bone is entirely divided. Not unfrequently the disc of bone can be grasped with forceps, and lifted out. In any case, some little portion of the inner table will have to be broken through.

The trephine disc, if it is to be replaced, may be at once put in a china receptacle containing a warm solution of corrosive sublimate (1 in 2,000), or sterilised water, and maintained at a temperature of 100° F.

In all cases every splinter and loose fragment of bone must be cautiously removed. Depressed fragments which still retain a hold upon the sound bone are left in position after they have been elevated.

The edges of the opening in the bone are finally smoothed off with the rongeur or the gouge.

The trephine disc or any large fragment of bone which has been preserved may be replaced as nearly as possible *in situ.*

The flap or flaps of scalp are now brought into place by silkworm-gut sutures, and drainage is secured by introducing a bunch of horsehair threads here and there between the stitches, or by a slight gauze drain.

II.—TREPHINING FOR ABSCESS OF THE BRAIN.

1. The Operation for Cerebal Abscess.—The trephining is carried out in the manner already described. In dealing with an abscess in the temporo-sphenoidal lobe a triangular flap, with its base above and behind, will be found to be convenient. This is held up by means of a ligature inserted into its apex.

The dura mater is exposed, and will usually be found to be without pulsation, and to bulge into the trephine-hole. This change in the membrane is a certain sign, not necessarily of pus, but of increased intercranial tension.

The dura mater is incised with the scalpel, and is then opened with the aid of fine scissors and delicate-toothed forceps. The division should be so made as to render the subsequent closure of the rents with sutures possible. A crucial incision will probably be the most convenient. The

aspirating needle having been introduced and pus dis-
covered, the next step is to insert a pair of slender sinus
forceps by the side of the needle, and thus to enlarge the
track along which the pus may escape.

Along the passage thus made a drainage-tube of india-
rubber or of silver is introduced. Mr. Barker advises a
silver tube, provided with a proper flange or shield, and
of the diameter of a No. 8 catheter. The silver tube,
however, is rarely at hand when the operation is performed,
and rubber answers well, as it allows of being shortened as
required. A double or two-way tube is very convenient for
syringing. The length of tube within the skull should
measure about one inch. The tube must be secured in place
by sutures. The flap is now adjusted, but the sutures may
be omitted at the apex of the flap, so that the trephine-hole
may not be entirely covered up, but there may be every
opportunity offered for the escape of matter.

The wound is now cleaned and covered with a dressing
of loose gauze. The part should be frequently irrigated,
and hence the special advantage of the two-way tube.

Any tube is apt to get blocked from time to time,
but can usually be cleared without removing it. The rubber
tube will be gradually shortened, and the surgeon should
not be in great haste to remove it finally, since a reaccumu-
lation of pus may occur. It will probably have to be
retained for two or three weeks.

If a branch of the middle meningeal artery be exposed
in the trephine-hole, it should be secured between two liga-
tures before the membrane is divided.

2. **The Operation for Cerebellar Abscess.**—
The trephining is conducted upon the same lines. Mr. Barker
recommends that the point be reached by means of an
incision parallel with Reid's base line, and half an inch
below it. The cut starts from the posterior border of the
mastoid process, and extends backwards for two inches.
Through this incision the superior curved line of the
occipital bone is exposed.

All the soft parts, together with the pericranium, are
peeled downwards with a rugine until the inferior curved

line is reached. Care must be taken not to wound the trunk of the occipital artery. The spot already indicated as most suited for the introduction of the trephine will lie just below the latter line. The bone here is very thin. The lateral sinus lies opposite to the superior curved line above and the mastoid process in front. The spot *for the trephine is a little behind and below the mastoid* foramen, and the direction in which it should work is upwards and slightly inwards. The bone may be removed with the trephine, or, if more convenient, with the gouge.

The dura mater is incised, the needle is employed, and the abscess is opened and drained in the manner already described. If the skin and soft parts on being released are found to overlap the trephine-hole, they must be divided in such a way as to leave the latter quite clear.

Mr. Barker recommends that as soon as the bone is exposed the mastoid foramen should be examined. If pus has found its way along the groove of the lateral pinus, it may induce symptoms akin to those of cerebellar abscess, and an examination of the foramen may reveal pus escaping, since that opening leads direct into the groove for the sinus.

CHAPTER II.

OPERATIONS ON THE MIDDLE EAR AND THE MASTOID ANTRUM.

PRELIMINARY CONSIDERATIONS.

THE floor of the middle fossa corresponds externally to a ridge passing back from the zygoma—its posterior root—towards the asterion, or meeting of the parietal, occipital, and temporal bones. This ridge can always be felt, as also a slight depression at its hinder end where the parietal bone fits in.

The lateral sinus grooves the mastoid process for one-third to one-half of its width, more deeply and extensively as a rule on the right side of the body than the left. Running down obliquely from the depression mentioned above to the anterior border of the mastoid process is a strongly-marked ridge produced by the insertion of the sterno-mastoid muscle. This ridge corresponds, as a rule, fairly closely with the anterior border of the lateral sinus.

As shown in Fig. 120, the operator may safely work in a triangle bounded above and behind by the two ridges described, and anteriorly by the wall of the external meatus. This triangle is nearly equilateral, each side measuring 2·5 cm. or 1 inch. The gouge, etc., should be made to traverse the bone inwards and slightly forwards, parallel to the meatus itself. In young children, especially, the cranial cavity is entered with ease, and this accident may have fatal results. It is most undesirable when opening a mastoid antrum full of pus to wound the lateral sinus, as the operation cannot be properly completed, and septic thrombosis is almost certain to follow.

TREPHINING THE MASTOID ANTRUM.

Instruments required.—The best instrument for opening the antrum is a sharp steel gouge, with a handle
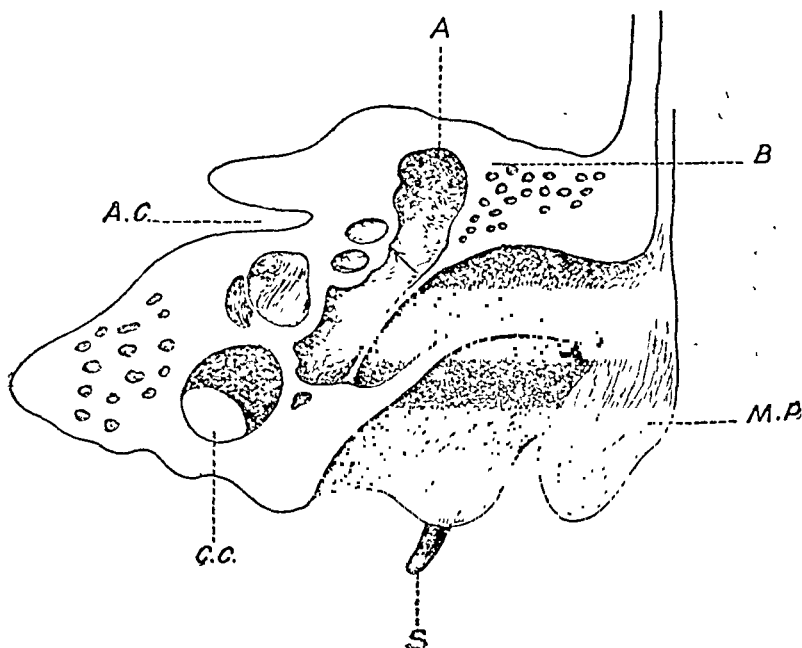
Fig. 119.—SECTION OF TEMPORAL BONE TO ILLUSTRATE THE COMPLETE MASTOID OPERATION. (*From specimen in London Hospital Museum.*)

The section passes downwards and forwards; the posterior half is shown.

M.P, Mastoid process; A.C, Canal for auditory and facial nerves; C.C, Carotid canal; A, Attic of tympanum leading into mastoid antrum posteriorly; S, Styloid process. The dotted line from B to the roof of the attic indicates the line of section required to remove the upper wall of the meatus and the air-cells, which·are often invaded by suppuration. The arrow inside the membrana tympani points to the canal of the facial nerve and the horizontal semicircular canal (both seen in section). Above the carotid canal is the cochlea.

ending in a broad round knob. Two gouges, one about 5 mm. wide in cutting edge, the other about 10 mm.; a metal mallet; fine flexible probe; curettes; Volkmann's

scoops; a syringe; and Stacke's protector should be at hand, besides the usual cutting and hæmostatic instruments.

Steps 'of the Operation.—The meatus is syringed out and cleansed as far as possible, the external ear and skin over the mastoid process disinfected. The adjacent scalp should have been shaved and the head enveloped in a sterilised towel over a waterproof cap. The auricle being held forward by an assistant, the surgeon makes a slightly curved incision downwards from the supramastoid ridge towards the apex of the mastoid process, parallel to the posterior wall of the meatus. A small transverse incision is usually required near the upper
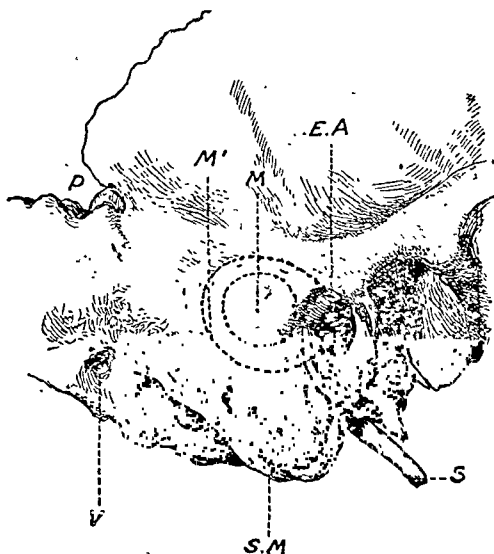
Fig. 120.—EXTERNAL SURFACE OF PETROUS BONE.

E.A, External auditory meatus; S, Styloid process; S.M, Rough surface of attachment of sterno-mastoid muscle. The supramastoid crest of bone is continued back to P, the postero-inferior angle of parietal bone; V, Mastoid foramen giving exit to a vein; M, Dotted circle indicating area cut through in trephining the mastoid antrum; M', Area of bone removed in the complete mastoid or radical operation.

end of the main one. The knife goes right down to the bone, with due care not to penetrate it in the case of a child's thinned mastoid process. With a rugine the soft parts are peeled backwards and forwards until an area corresponding to the dotted line M in Fig. 120 is exposed. The bone enclosed by this line is then gouged away bit by bit.

The instrument is directed forwards and inwards parallel with the long axis of the meatus.   It is convenient to introduce a short piece of pencil or of gum-elastic catheter into the meatus as a guide, and to keep the gouge exactly parallel with it.

If the instrument be directed inwards at right angles to the surface of the skull at the point indicated, the antrum will certainly be missed, and the lateral sinus almost as certainly opened.   The direction followed by the gouge is therefore of the utmost importance.

In the adult the antrum will be reached at a depth not exceeding three-fifths of an inch.   The loss of resistance and the escape of pus indicate when the cavity is opened.

The opening is enlarged to the desired extent by means of the sharp gouge.   If any necrosis be present, the gouge will need to be liberally employed.

The tunnel in the bone having been well syringed out, a suitable drainage-tube is inserted, and the parts are well dusted with iodoform.

Boracic fomentations form the most suitable dressing. Gentle syringing with weak antiseptic lotions should be employed daily, followed by gauze dressings.   When all purulent discharge has ceased, the opening may be allowed to close.

THE COMPLETE OR RADICAL MASTOID OPERATION.

In certain cases of long-persisting otorrhœa with marked loss of hearing, an operation is performed which involves removal of the remains of the membrana tympani, the small bones of the ear, and the posterior wall of the meatus, so as to convert the tympanum and the mastoid antrum into one cavity.   This is lined either by flaps from the soft tissues of the meatus or by epithelial grafts (Fig. 119).

MR. BALLANCE'S METHOD.

" *The First Operation.*—The incision is made behind the pinna, and the latter held forward with a rake retractor. A round cross-cut burr, driven by an electric motor, is used

to open the bony cavity, but when no motor or burr is available a gouge is recommended; and while this is being used a Stacke's protector serves to shield from injury the tuberosity which projects from the inner wall into the neck of the antrum, and contains the Fallopian aqueduct and the horizontal semicircular canal. The posterior wall of the osseous meatus is removed with a pair of small angular bone cutting forceps. Sharp spoons of various sizes are used to move the diseased granulations and soft parts from antrum, attic, and tympanum. The tegmina antri and tympani, and the inner walls of these cavities, should be left by the spoon clean and hard. A bright light is required to do this well, and temporary plugging with dry gauze is an important aid. The cartilaginous canal is next dealt with. Its inferior wall is divided vertically well into the concha. The cut in the concha is then carried with a curve upwards and backwards till it reaches the level of the anterior commencement of the helix. The posterior wall of the meatus is then pushed upwards and backwards, and attached in a special manner by one, two, or three silkworm-gut threads to the mastoid flap. The bone cavity is then plugged with gauze through the meatus.

"Under favourable circumstances the second operation may be done a week later, but in adults not for two or three weeks.

"*Description of Second Operation.*—An anæsthetic having been given, the original incision is again opened; this being easily accomplished by the handle of the knife. The pinna is now displaced forwards, and care taken to arrest all oozing from the granulating surface. The tympano-antral cavity must be rendered quite dry by little pieces of gauze held on forceps. Large epithelial grafts, as thin as possible, are now taken from the thigh or arm. If the surgeon is successful in cutting an epithelial graft large enough to cover the whole area of the granulating surface, it can be applied with advantage in one piece. The graft is best carried to the wound spread out on a microscopic section lifter. It should be made to cover (1) the anterior wall of the cavity formed internally by the anterior boundary of

the tympanum and attic, and externally by the anterior wall of the enlarged osseous meatus; (2) the anterior part of the roof of the cavity formed by the tegmen tympani and the superior wall of the enlarged osseous meatus; (3) the inner walls of the attic and tympanum; (4) the tegmen antri; (5) the ridge formed by the Fallopian aqueduct; and (6) the inner wall of the antrum.

"As an aid in pressing the epithelium graft firmly into the cavity, steel probes or stoppers are recommended with pear-shaped heads. As a protective to the grafts, gold-leaf should be applied over them and carefully pushed into position, after which a narrow strip of dry iodoform gauze is packed into the cavity and allowed to remain for a week. The gold-leaf may be left undisturbed for three or four more days; it should then be removed with forceps."—*Dr. W. H. Harsant's Abstract of Mr. Ballance's Paper.*

CHAPTER III.

Excision of the Eye-Ball.

Instruments required.—Eye speculum ; strabismus hook ; strabismus scissors ; toothed forceps ; blunt-ended scissors curved on the flat ; small sponges.

The Operation.—The patient's head is a little raised, and the surgeon stands in front, facing the patient.

The speculum is introduced between the lids and opened.

With the blunt-pointed scissors the surgeon snips through the conjunctiva just behind the corneal margin. The toothed forceps are used to pick up the membrane and to steady the globe. The division of the conjunctiva is complete all round.

By the further use of the scissors Tenon's capsule is freely opened, and each of the rectus tendons is then picked up in turn with the strabismus hook, and is divided close to the sclerotic with the strabismus scissors. It is convenient to begin with the external rectus, then to divide the superior and inferior recti, and to finish with the inner rectus. If the speculum be now pressed back into the cavity of the orbit, the eye-ball starts forwards. The blunt-ended scissors curved on the flat are then introduced into the orbit to the outer side of the globe, and are carried back until the optic nerve is reached. It is divided by one cut of the blades.

The eye-ball being drawn forwards with the fingers, the oblique muscles are divided, together with any soft parts which may still hold the globe in place.

A piece of Turkey sponge is then pressed into the cavity of the orbit, and is allowed to remain there for a few minutes.

The first dressing consists merely of an aseptic sponge pressed into the cavity of the orbit over the closed eyelids, and retained in position by a pad and bandage. This is

taken out at the end of twelve hours or earlier, and the subsequent treatment consists of daily irrigations, and the dressing of the part with a pad of wool soaked in boracic lotion.

If the globe be collapsed, as is frequently the case when excision is carried out, the operation becomes a very meagre affair, scarcely removed from the humble procedure of detaching a slough with scissors and forceps.

It is well in these cases, however, to take care to remove the globe alone, and to leave the muscles with as little of their substance displaced as possible.

Part XIV.

OPERATIONS ON THE BREAST.

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EXCISION OF THE BREAST.

Instruments required.—Several large and small scalpels. If one knife is used for cutting into the tumour, it should be at once laid aside and another taken. Dissecting and sharp-pointed forceps; fifteen to twenty Wells's pressure forceps; two pairs of scissors; aneurysm needle (occasionally wanted); vulsellum forceps; blunt dissector; needles, sutures, and needle-holder, etc.

Position.—The patient is brought to the edge of the table, and lies with the head and shoulders raised. The arm of the affected side is well raised from the side and securely fixed by a bandage applied with clove-hitch round the wrist to the head of the table, so that it cannot move during the operation.

The axilla has been thoroughly shaved and disinfected beforehand. The arm, neck, and abdomen are protected by macintosh sheeting, over which sterilised towels are placed.

The Incision, etc.—The exact incision made will vary according to the individual case, though its general form will be elliptical, the centre of the ellipse being about the nipple. The upper end of the incision used to be made through the centre of the axilla, but it is much better to place it well over the border of the pectoralis major muscle, tailing slightly downwards across the insertion of the latter (see Fig. 121). The reasons for this are: (1) The axillary skin is provided with large hair-bulbs and modified sweat-glands. It is practically impossible to

render these aseptic, and hence the wound should not be
made through this region of skin.   (2) In many cases,
probably in all, it is best to remove with the breast the
costal or lower portion of the great pectoral muscle, and
this is rendered easy by this modification of the old incision.
(3) Clearing the axilla, especially the upper part of it
between the clavicle and first rib, is done by open dissection
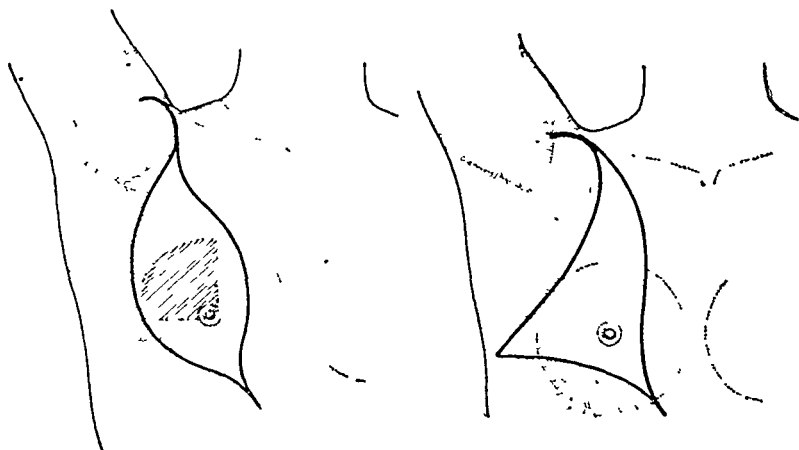
Fig. 121.—INCISIONS FOR REMOVAL OF BREAST AND CONTENTS OF AXILLA,
   SHOWING MODIFICATIONS ACCORDING TO THE AMOUNT OF SKIN
   REQUIRED TO BE REMOVED.

In the left figure the shaded area (the upper and outer quadrant of
   the breast) indicates that part in which scirrhus commences in nearly
   three out of four cases.   In both figures the wound is placed in
   front of the axilla, and its upper end curves over the pectoralis
   insertion.

through this incision.   By the mid-axillary one this step
was effected mainly by finger traction in the dark, with
increased risk of venous hæmorrhage.

When adhesions exist between the skin and tumour,
the former must be freely sacrificed, as a slight delay in
healing of the wound is of no importance compared with
the risk of leaving nests of cancer-cells behind.   In some
cases it is advisable to excise a V-shaped piece of skin

covering the outer part of the · breast as well as that removed by the modified elliptical incision. (See Fig. 121.)

In dealing with the right side, the surgeon commences the incision over the axilla and cuts toward the chest.

In dealing with the left breast, it is convenient to commence the incision at its lower part, and cut towards the axilla.

In either case the lower or axillary half of the incision is made first for convenience as to the bleeding. The flap is retracted by careful dissection until the posterior fold of the axilla (edge of the latissimus dorsi) is reached.

As the cut is made, the surgeon steadies the part with his left hand, which is made to press in the opposite direction to that followed by the knife, so as to keep the skin tense.

The knife should at first involve the skin and superficial tissues only, and should just pass down into the subcutaneous fat. As soon as the ellipse has been completed the surgeon should turn to the V-shaped point at each extremity of the wound, and should see that the skin is entirely free at these points. It is very common for the mass to be held here, owing to a faulty division of the skin.

The chief assistant, who stands upon the opposite side of the table, now draws the skin up on the sternal side of the mamma towards the median line, while the surgeon lightly presses the breast downwards with his left hand. While the parts are in this position the upper limb of the incision is carried down to the pectoral muscle If the skin be fully retracted by the assistant, a division of the deeper parts well beyond the limits of the breast is ensured.

The surgeon now grasps the mamma and drags it away from the thorax, while he severs its deep attachments in such a way as to lay bare the great pectoral muscle. The fascia forming the sheath of this muscle should always be removed, and it makes little difference as regards future use of the arm whether the whole thickness of the costal portion be taken or not. As its removal greatly helps a thorough clearance of the axilla, it may be advised in nearly all cases. In dividing the muscle close to its origin from the sternum

and costal cartilages the anterior perforating vessels must not be cut too close to their points of emergence. As a rule they can be secured by pressure forceps before being cut across.

The breast, with the underlying muscle, is now drawn downwards and outwards, and the pectoral insertion divided cautiously so as to expose the axillary vessels, the incision being made at right angles to the fibres. With ordinary care there is no risk of damaging the axillary vein, as a layer of fascia and some fat separate the muscle from it.

Some surgeons recommend that the pectoralis minor should invariably be removed at the same time. This is not always necessary, and somewhat increases the severity of the operation. In completing the removal of the breast and axillary contents, the serratus magnus, the subscapularis, the axillary vessels, and nerves will be laid bare. It is well to expose the vein early, and the handle of the scalpel or a blunt dissector will be used to detach the chain of lymphatic glands which runs alongside it. Now and then it may be necessary to excise part of the axillary vein between two ligatures in order to get away adherent glands. This should be avoided, if possible, as the cephalic vein may be deficient, and œdema of the arm is then apt to follow.

The intercosto-humeral nerve will often require to be divided, leading to subsequent numbness at the lower and inner part of the arm, but the subscapular nerves, the corresponding artery and vein, and the long thoracic nerve should be spared. Branches of the subscapular and axillary vessels to the lymphatic glands will necessarily be divided, and all such vessels should, if possible, be clamped before their section.

Careful search should be made for the lymphatic glands which lie close to the coracoid process and first rib, and they should be removed, whether apparently infected or not.

It is now convenient to mention the following *general points* with regard to excision of the breast: (1) All bleeding points should be picked up neatly, and not grabbed

up together with a mass of the surrounding tissue. (2) The wound should not be scrubbed with a sponge. It barely needs to be sponged at all. (3) Sterilised water should be used to wash the wound. It should be cleansed by washing and not by sponging. A kidney-shaped receiver is placed beneath the wound, and a stream of warm sterilised water is allowed to run over the raw surface until all clots have been washed away.

The bleeding points are now dealt with. In the majority of cases the long-continued pressure of the forceps will suffice to close the larger number of the vessels, others are occluded by twisting the pressure forceps when they are removed. But as recurrent hæmorrhage is more common after excision of the breast than any other operation, it is best to tie every doubtful vessel with catgut or fine silk. When this has been done and the cavity has been flushed with warm sterile water, the long wound is sewn up.

The needles employed are straight and long, and the sutures are of silkworm gut. The upper and lower sutures are applied first, the middle ones being left to the last. The sutures are not tied until the upper and lower series are completed. They are then knotted, and the assistant follows the closing wound with sponges, so applied as to maintain considerable pressure over the recently-united incision, and to obliterate the wound cavity. This pressure must not be relaxed. In a few cases an opening for a drainage-tube is now made in the hollow of the skin below the wound. A tube is inserted and secured by a suture. The drainage-tube can easily be dispensed with, and it appears to increase the risk of suppuration.

The middle sutures—*i.e.*, those in the central part of the wound—are now inserted and, when they are all in place, tied. The assistant with the sponges still follows the sutured incision, and obliterates by pressure the wound cavity. The dressing is prepared. It consists of a large pad of sterilised gauze or dry cyanide gauze, over which sterilised wool is used. The wool covers the whole side of the chest, the opposite breast, the shoulder, and the back as far as the spine.

Until recently it was the custom, after excision of the breast, to bandage the arm of the same side against the chest wall—making, in fact, a splint of it—to keep the dressings at rest. It was usual to maintain the patient's arm in this position for ten days or so, allowing movement neither at shoulder nor at elbow-joint, and sometimes even confining the fingers and hand closely against the thorax. Such confinement is, of course, irksome to the patient, and apt to be followed by stiffness of the joints, which is but slowly recovered from. The axillary vein may become adherent to the side of the chest, and circulation be thereby impeded. Moreover, keeping the arm pressed against the side of the chest encourages axillary perspiration, and may thus favour infection of the wound. As long as the shoulder-joint is kept at rest, freedom of the elbow and hand cannot interfere in the least with the healing of the wound. The best way is to envelop the axillary and pectoral region with a large dressing, which is kept securely in place by a figure-of-eight bandage applied whilst the assistant supports the arm at about a right angle from the chest wall. The arm is subsequently supported on a pillow at a little less than this angle.

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